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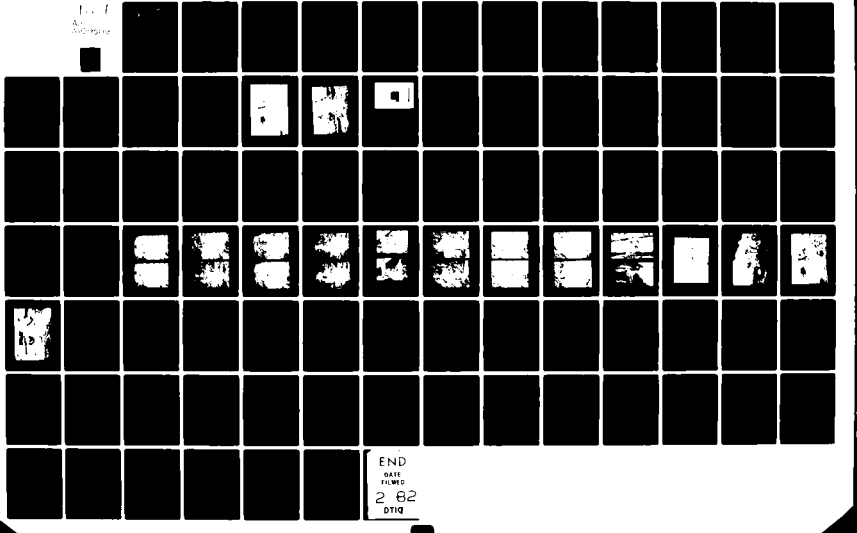

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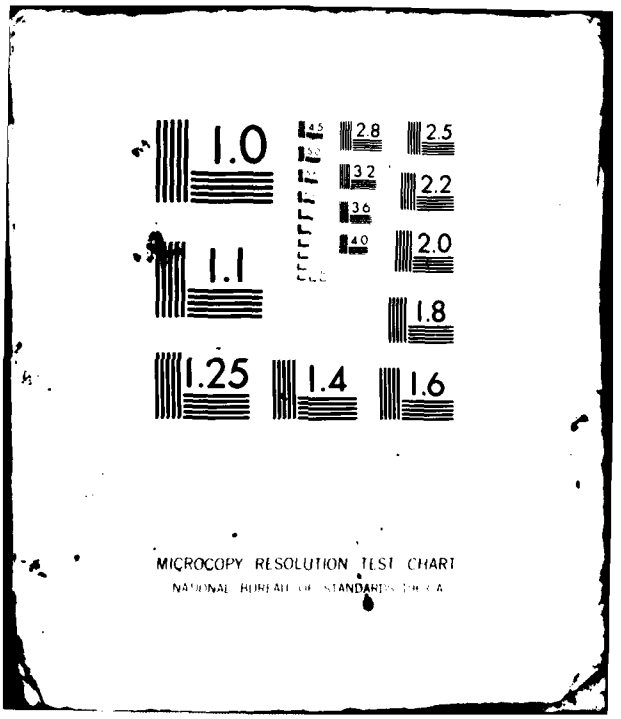
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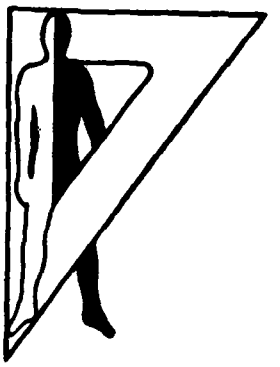

Technical Memorandum 15-81

MEDIUM ANTITANK WEAPON (MAW) PORTABILITY FOR THE MECHANIZED INFANTRY

Samuel T. Brainerd
Dominick J. Giordano

September 1981
AMCMS Code 612716.H700011

U. S. ARMY HUMAN ENGINEERING LABORATORY
Aberdeen Proving Ground, Maryland

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Twenty marines carried thirteen different loads consisting of components of generic, medium antitank weapon (MAW) systems over courses of 150, 300, and 600 meters. The speed of portage and the subjects' ability to track a moving target after portage were measured. The subjects' opinions and ratings of the loads were recorded. The results suggested that, although portage pace was inversely proportional to load weight, the subjects were not overloaded by the weights they carried. Furthermore, tracking errors were not

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20. ABSTRACT (Continued)

affected by the weight of the load carried. It was concluded that, for the short portage distances required by the mechanized infantry, the MAW gunner can carry antitank systems heavier than the Dragon.

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EXECUTIVE SUMMARY

Portability of medium antitank weapons (MAWs) and tracking accuracy after portage were studied in a field experiment conducted during October 1979. Twenty enlisted marines carried various configurations of MAWs to an over-watching, defensive position and simulated firing at a moving target. The weapons were carried 150, 300, and 600 meters with the last portion of each carry being a steep slope to the firing position. The subjects tracked the moving target 1 minute after portage; half using a bipod-mounted system (Dragon) and half using a viscously damped system (TOW).

Portage times and rates were measured for each of the configurations and methods of carry. Tracking standard deviations in azimuth and elevation were calculated. The subjects' ratings and opinions on the portage and tracking portions were recorded on a questionnaire.

The 13 different loads were each made up of two or more components of the weapon systems. With these configurations, portage by one soldier or by teams of soldiers was investigated, so the time required to transport more than one round to the firing position was calculated. The two weapon systems tested were a Dragon with tripod and integrated sight (Dragon IST) and a Prototype Lightweight TOW (PLTOW), both representing generic MAWs for mechanized infantry use.

Portage pace was inversely proportional to load weight for each course length. This relationship was linear throughout the course lengths, so the subjects were not considered overloaded even with weights totaling 47 kilograms (104 pounds) of weapon system and basic combat gear, as long as loads were carried no more than 600 meters. Stretcher loads were carried at a significantly slower rate than the equivalent weight per carrier in the individually carried loads.

Tracking errors did not appear to be related to load weight or portage distance. Tracking after portage was significantly worse than rested tracking. Tracking with the bipod system showed a greater frequency of errors and higher peak values than tracking with the viscously damped system. The gunner's shoulder must support the weapon to track and fire, so heavy breathing after portage probably affected tracking with the bipod system.

The most important conclusion of the study was that, for the short distances required by the mechanized infantry, the MAW gunner can carry weapon systems heavier than the Dragon.

It is recommended that mechanized infantry units be equipped with heavier and more effective MAWs than those used by light infantry because their portability requirements differ.

MEDIUM ANTITANK WEAPON (MAW) PORTABILITY FOR THE MECHANIZED INFANTRY

INTRODUCTION

A previous study by the US Army Human Engineering Laboratory (HEL) (4) showed that the Dragon weapon system is beyond the limit of portability for light infantry. The Dragon gunner's load (including his clothing, equipment, and rifle) weighs 33 kilograms (72 pounds), roughly half the body weight of the average American soldier (8). The most commonly agreed-upon limit of portability for extended operations is 30 to 40 percent of body weight (6).

The Dragon cannot defeat new armor, so a need exists for a medium antitank weapon (MAW). Should this weapon weigh more than the Dragon, it would also be too heavy for light infantry, but possibly not be overweight for the mechanized (mech) infantry. The portage distance requirements for mech infantry are less stringent than those for light infantry: a review of literature and terrain maps for European defense areas indicated portages of 75 to 150 meters to reach primary firing positions and 300 to 600 meters to reach alternate positions. Soldiers in the mech infantry do not have to carry their weapons as far as their counterparts in the light infantry, so they should be able to carry more weight.

The loads carried during this study were mock-ups of various subsets of generic antitank weapon systems. A variety of complete weapons systems were composed by combining two or more of these subset loads differing in the type of missile and in the number of extra rounds and crew members. The penalty incurred by carrying an extra round or two to the firing position was then assessed.

The Dragon with integrated sight and tripod (Dragon IST) and a Prototype Lightweight TOW (PLTOW), developed by Hughes Aircraft Corporation, were the two MAW systems used in the study. The PLTOW is designed to fire a TOW missile using a launch tube, a tripod, and guidance electronics which are lighter than the standard TOW. The Dragon IST system consisted of the standard Dragon launch tube and round with models of a proposed, integrated day and night sight and a viscously damped tripod. These extra components were added to the Dragon system for this study to make it more comparable to the PLTOW, which also used an integrated sight and a viscously-damped tripod.

The combat scenario simulated transporting the soldiers and their weapon systems by vehicle to a point close to a firing position. The soldiers were required to rapidly carry their portions of the weapon system up a slope and immediately prepare to engage an enemy target.

PURPOSE

The purpose of this field study was to determine if system weights and methods of carry affect the portability of medium antitank weapon systems in the mechanized infantry.

OBJECTIVES

1. Determine the relative portability of MAW systems weighing more than the standard Dragon for the mechanized (mech) infantry.

2. Determine the effect of portage on subsequent tracking performance.

3. Determine the usefulness of stretchers for carrying MAW systems.

METHOD

Test Area

This study was conducted at the Churchville Automotive Testing Area, Aberdeen Proving Ground, MD. The site was chosen primarily for its steep hills and packed-dirt roads. Three test courses with a common finish line were established along a 600-meter road. An area adjacent to the finish line was used for a tracking task. The layout of the test site is shown in Figure 1, and Figure 2 illustrates the terrain profile of the 600-meter course.

Subjects

Twenty male enlisted marines participated as subjects in the study. Five of the marines had prior training on TOW and Dragon simulators, and three others had trained only on the Dragon simulator. One of the twenty had actually fired the Dragon missile; none had fired a TOW missile. Data on the subjects' demographics and firing experience are contained in Table 1.

Apparatus

Clothing and Equipment

Each subject wore and carried a specific ensemble of clothing and equipment throughout the study (see Table 2). The total weight of this basic combat load was 18 kg (39.7 lbs).

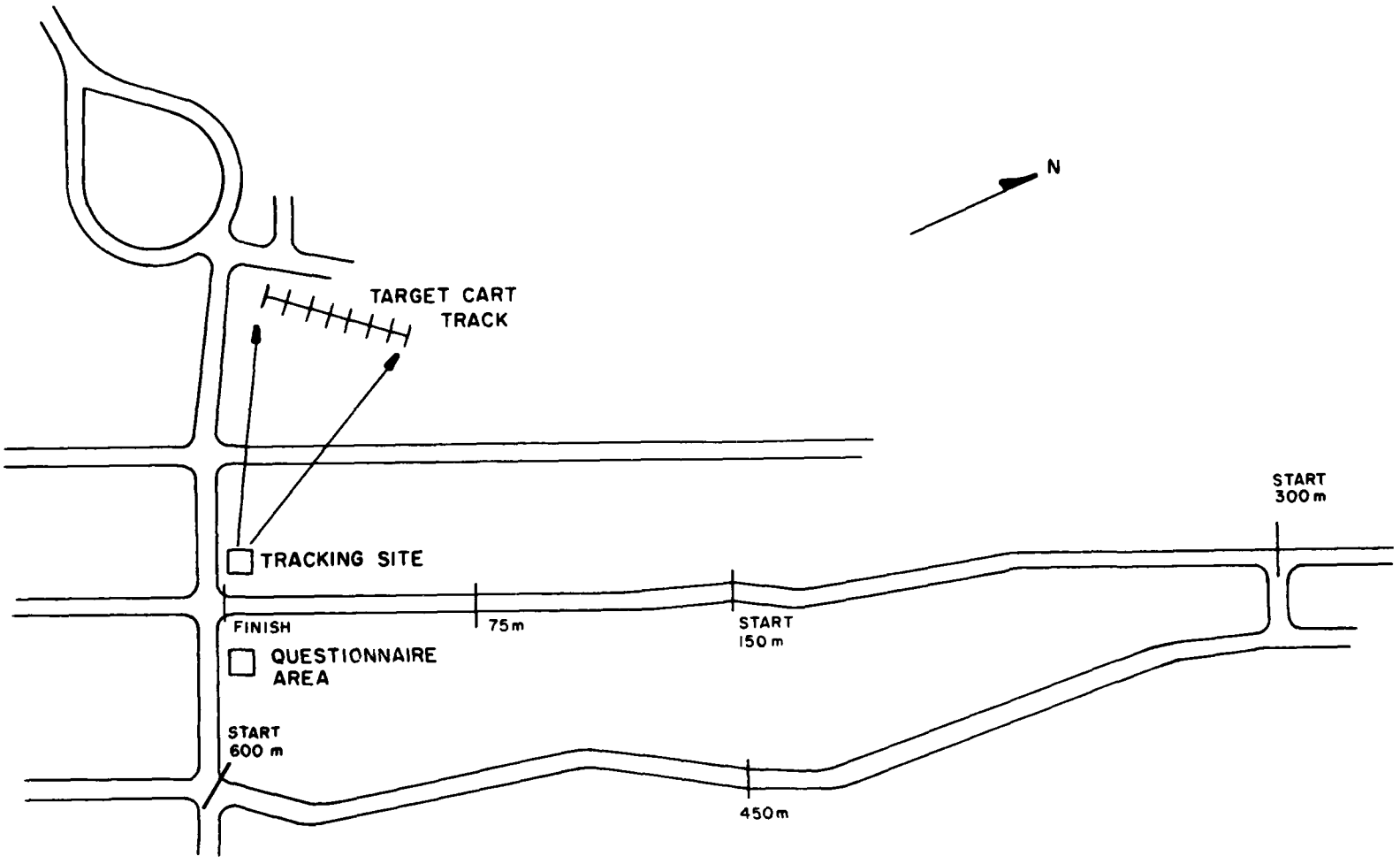

Figure 1. Test area.

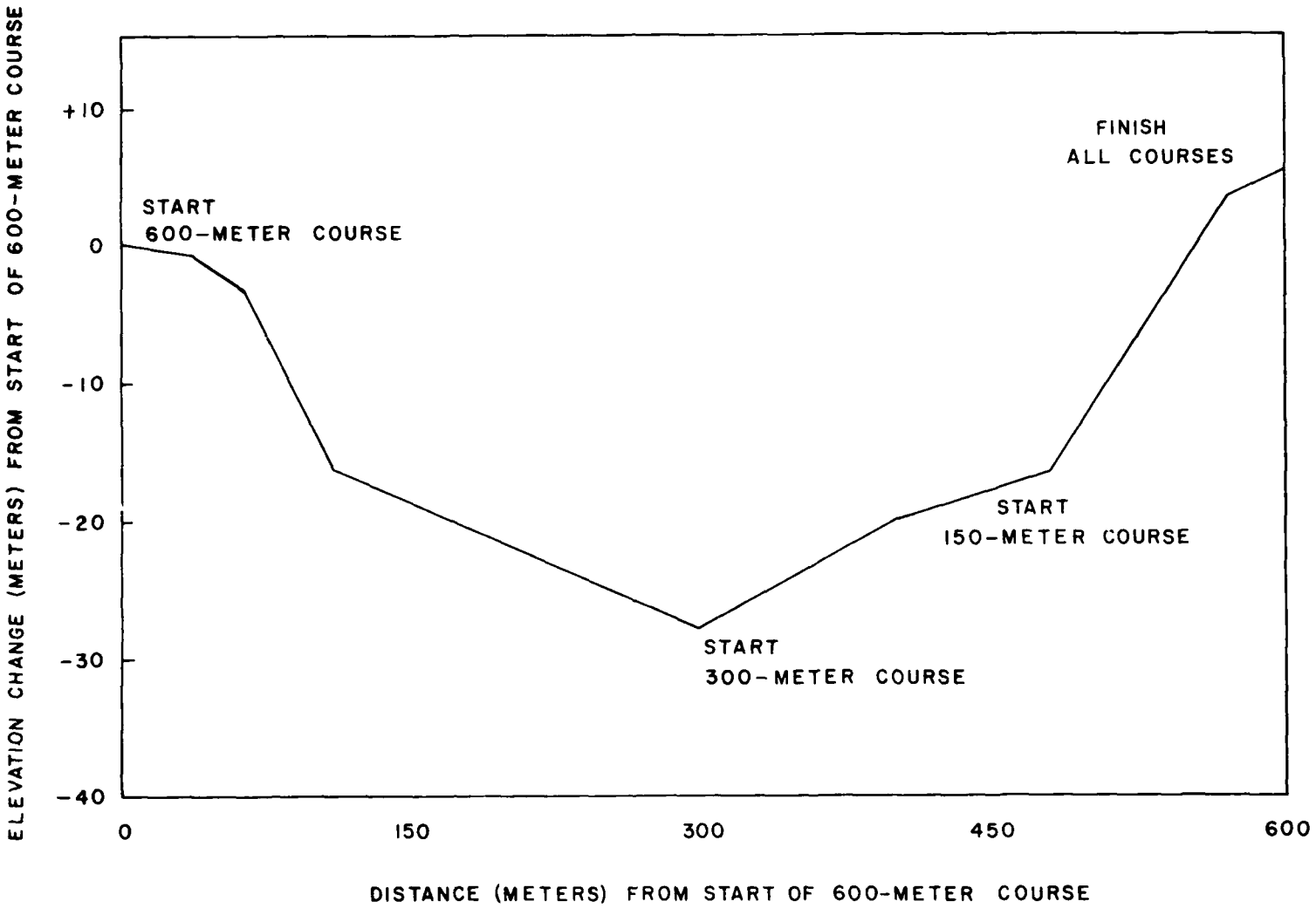

Figure 2. Terrain profile of test courses.

TABLE 1

Physical Characteristics and Military Experience of Subjects

Subject Number	Age (Years)	Height (cm)	Weight (kg)	Rank	Time in Service (Months)	MOS	Previous Training
2	22	183	69	E-5	44	0311	No
3	22	183	75	E-5		0311	Yes: Dragon (live rd.), TOW
4	22	180	70	E-4	40	0311	Yes: Dragon
5	22	183	86	E-4	18	0311	No
6	19	180	86	E-3	14	0311	No
7	21	180	77	E-3	15	0311	No
8	19	175	67	E-2	12	0311	No
9	20	191	82	E-3	28	0311	Yes: Dragon and TOW
10	20	165	61	E-3	25	0311	Yes: Dragon and TOW
11	19	183	77	E-1	12	0311	No
12	20	185	78	E-3	28	0311	Yes: Dragon
13	21	180	75	E-3	40	0311	Yes: Dragon
14	19	173	59	E-3	31	0311	No
15	19	168	68	E-3	16	0311	No
16	23	173	68	E-2	36	0311	No
17	19	168	59	E-2	28	0311	No
18	21	168	65	E-3	41	0311	Yes: Dragon and TOW
19	20	168	66	E-2	28	0311	No
20	20	175	72	E-1	29	0311	No
21	19	180	79	E-3	27	0331	No
MEAN	20	177	72		27		

TABLE 2

Basic Combat Gear
(Common to All Subjects)

Item	Weight (lbs)
Utility Jacket and Trousers	2.3
Boots, Combat, DMS	3.3
Belt, Trousers, Utility	0.2
Underwear	0.6
Belt, individual equipment with suspensers and pouch	1.5
Entrenchment Tool with Carrier	2.5
Canteen with Carrier	3.3
Mask, CB, M17A1	3.0
Pouch, Ammo, 30 rounds (2 each)	0.7
Ammunition, 5.56mm, 6 mag., 30 rounds each	4.1
Grenade, Fragmentation, M26 (2 each)	2.0
Vest, ICM	8.0
Helmet, M1	3.3
Rifle, M16A1 with sling and loaded magazine (mock-up)	4.9
Total Basic Combat Gear	39.7 (18.0 kg)

MAW Loads

The loads carried by the subjects for each trial consisted of wooden mock-ups of components of MAW systems. Table 3 lists these components and their weights. (Note that the Dragon IST tube was not a mock-up but an actual expended Dragon round weighted to duplicate an unfired Dragon missile.)

TABLE 3

Weapon System Components

	Weight (kg)
Dragon IST	
1. Launcher and Round	11.3
2. Integrated Day and Night Sight	10.9
3. Viscously-Damped Tripod	6.8
PLTOW	
1. Round	23.6
2. Launch Tube and Tripod	14.1
3. Integrated Day and Night Sight	15.9
4. Traversing Unit	9.9

The mock-ups accurately represented the system components in regard to overall dimensions, general shape, total weight, and center of gravity. Projections, bulges, and corners that were liable to affect portability were present. The smaller features and details of the weapon systems were not built into the mock-ups.

Timing

Manually operated, mechanical stopwatches were used to measure the duration of each portage trial and the interval between the trial and the ensuing tracking task.

Transportation

A pickup truck was used to transport the subjects from the loading zone to the start line before each carry.

Communication

Five hand-held radios provided the means of communication among the test personnel.

Tracking

Two different antitank weapon systems were used as tracking devices: the M47 Dragon Medium Antitank Assault Weapon System, and the TOW Heavy Antitank Assault Weapon System.

The Dragon tracking system consisted of a spent Dragon launcher and bipod with a tracker attached. A Milliken DBM-4C 16mm motion picture camera, with a 150mm lens, was mounted on a bracket in front of the launch tube (Figure 3) and aligned with the tracker's optics. The camera increased the weight of the Dragon tube by 4.5 pounds but did not seem to affect the operational characteristics of the system.

The TOW system was operational except a spent round was mounted in the launcher and the missile guidance set was not connected. A Milliken DBM-4C 16mm motion picture camera, with a 150mm lens, was mounted on a bracket attached to the TOW's traversing unit (Figure 4). The camera added 4.5 pounds to the system but did not appear to change its tracking characteristics.

The filming rate of the Milliken cameras mounted on both the TOW and Dragon was 12 frames a second.

Since the TOW's optical sight could not focus on a target as close as 75 meters, a 3-power rifle scope was mounted on a bracket immediately above the eyepiece of the TOW sight. The camera and rifle scope were aligned. The slight change in posture required by the use of the rifle scope did not seem to affect the subjects' tracking performances.

Moving Target

The target used in the tracking portion of the study was a 3'x3' white square of plywood with two 4"x4" black squares in the center (Figure 5). The target was mounted on an electrically powered cart designed and built by HEL.

The target cart traversed a 17-meter section of track in approximately 32 seconds, yielding an angular rate of 7 mils a second as seen from the tracking station 75 meters away. The start and finish of the track were marked by white stakes, plainly visible from the tracking station.

The cart was started by a remote switch and was automatically stopped at the end of each trial by a cam-activated switch. It was returned to the start position at the conclusion of each trial.

Stationary Boresight Target

A stationary target at one end of the target path was used for boresighting and trial identification. This target board was the same design as the moving target, except several hooks were added at the base to

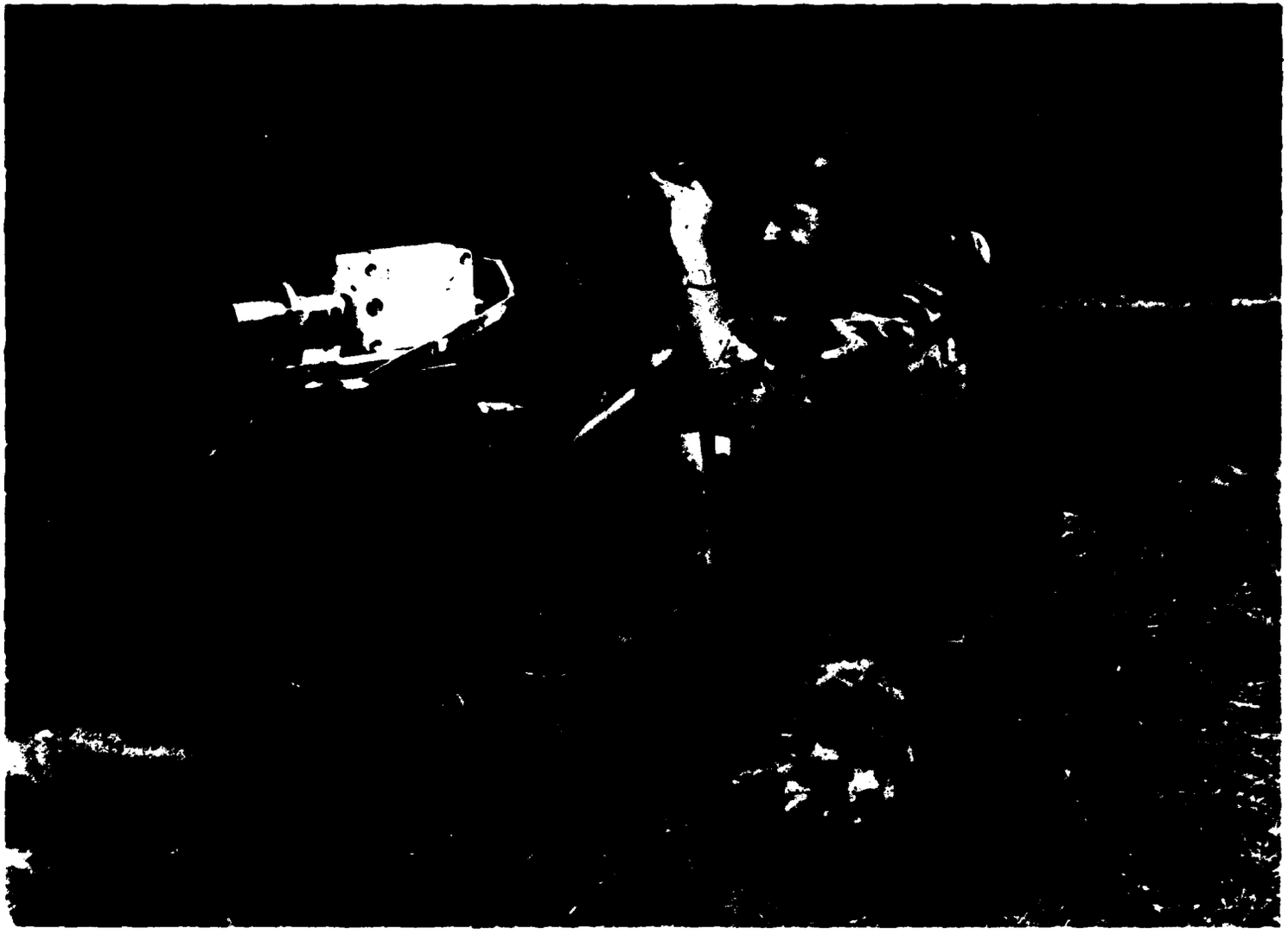

Figure 3. Dragon tracking device.

Figure 4. TOW tracking device.

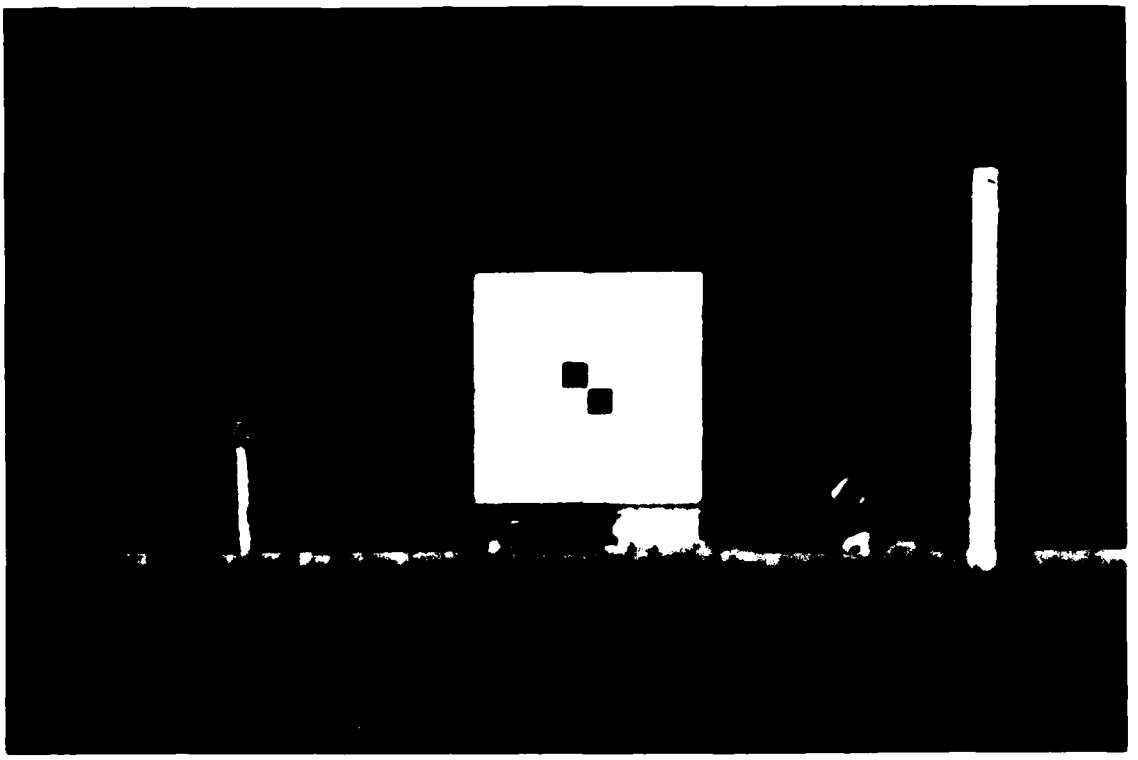

Figure 5. Target cart and board.

mount trial identifiers (run numbers, subject numbers, and tracking device numbers).

Independent Variables

MAW Loads

Thirteen different loads were carried during this study: five formed from mock-ups of the Dragon IST weapon system and eight from mock-ups of the PLTOW system. All the Dragon IST loads and two PLTOW loads were carried individually. The components were slung over the shoulders or strapped to All-Purpose Lightweight Individual Carrying Equipment (ALICE) pack-frames and carried on the back. The ALICE pack-frames weighed 1.4 kilograms (3 pounds).

The remaining six PLTOW loads were mock-ups strapped to three 2.8 kilogram (6-pound) stretchers made of aluminum tubing and canvas. Since the front and the rear of a stretcher were considered separate loads, the three stretchers accounted for six different loads.

The 13 loads, components of each load, component weights, and total weight of each load are listed in Table 4. Loads 1 through 8 were carried during Phases 2 and 3; Loads 1 through 4 were carried during Phase 4; and Loads 9 through 13 were carried in Phase 5. Photographs of the test loads are contained in Appendix A.

TABLE 4

Medium Antitank Weapon (MAW) Loads

Load Number	Components and Components Weights (kg)	Weight (kg) Total	Weight (kg) Per Subject
1	Two Dragon rounds, slung (11.3 each).	22.7	22.7
2	Dragon round (11.3) and tripod (6.8), slung plus sight (10.9) on pack frame (1.4).	30.4	30.4
3	Dragon round (11.3) and tripod (6.8) on pack frame (1.4).	19.5	19.5
4	Dragon round (11.3) and sight (10.9) on pack frame (1.4).	23.6	23.6
5	Front of stretcher (2.7) containing two PLTOW rounds (23.6 each).	49.9	25.0
6	Rear of the stretcher in Load 5.	-	25.0
7	Front of stretcher (2.7) containing PLTOW round (23.6), tube & tripod (14.1), sight (15.9), and traversing unit (9.9).	65.3	32.7
8	Rear of the stretcher in Load 7.	-	32.7
9	Front of the stretcher in Load 7, plus shoulder straps (0.5).	65.8	32.9
10	Rear of the stretcher in Load 9.	-	32.9
11	Dragon round (11.3) slung, plus tripod (6.8) and sight (10.9) on pack frame (1.4).	30.4	30.4
12	PLTOW round (23.6) and traversing unit (9.1) on pack frame (1.4)	34.0	34.0
13	PLTOW tube & tripod (14.1) slung, plus sight (15.9) on pack frame (1.4)	31.3	3.13

Courses

The subjects were required to carry the loads over courses of 150, 300, and 600 meters (see Figures 1 and 2). The 150- and 300-meter courses were subsections of the 600-meter course and had the same finish line. The first half of the 600-meter course was downhill, with slopes of -12% and -6% for the first and second 150-meter segments. The second half of the 600 meters (which doubled as the 300-meter course) was uphill with slopes of +7% and +17% for the two 150-meter segments. The final 150-meter segment of the 600-meter course was used for the 150-meter carries.

Dependent Variables

The dependent measures in this study were the portage times (in seconds), portage paces (in meters-per-second), tracking performances (in mils), and the responses of the subjects to a questionnaire designed to assess their reactions regarding the portability of the loads.

PROCEDURE

Phase I: Training Phase

The subjects had to complete both a portage task and a tracking task during the study, so two periods of training were scheduled. The first training period was for the tracking task done in an open field near the HEL Mobility and Portability Test Course, Aberdeen Proving Ground, MD. The TOW and Dragon tracking devices used during this phase are described in the Apparatus section. The target board was attached to the hood of a jeep in lieu of being mounted on the electric cart. A set of numbers, hung on the side of the jeep, identified the tracking device and the training trial number.

Ten subjects were assigned to track with the TOW and 10 with the Dragon. Each subject received individual instruction on how to track from a kneeling position with the TOW or Dragon, and 10 training trials: five as the jeep traveled from left to right at 4 mph and five as it traveled in the opposite direction at the same speed.

The second training period was for the portage task. This training period was briefer than the tracking training because the physical condition of the subjects was already at a high level after just completing a study conducted by HEL involving several weeks of physical activity (obstacle course runs and cross-country marches), and the subjects needed only a few runs to become familiar with the portage course which was a wide, packed-dirt road with no obstacles other than some ruts and steep slopes.

The portage training period consisted of two untimed group runs over the full 600-meter course and one timed 600-meter trial in which the subjects ran in pairs. The subjects carried only basic combat loads during these trials.

Phase 2: 150-Meter Carries

During this phase, every subject carried Loads 1 through 8 once over the 150-meter course for a total of eight trials. The order in which the loads were carried is contained in Appendix B. The subjects ran the course in pairs, one subject trained to track with the TOW and the other trained on the Dragon.

The pairings were random and changed from trial to trial. At the start of a given trial, the two subjects were alerted and told to put on their basic combat gear. The subjects with their loads were then driven in a pickup truck to the start of the 150-meter course. At the start line, the subjects put on their loads and prepared for the trial. The subjects began the run up the slope at the experimenter's signal. Their times were recorded to the nearest second at the 75-meter mark and at the finish.

When they reached the finish line, the subjects removed their loads and waited 1 minute before beginning the tracking task. The 1-minute interval did not start until the slower subject had crossed the finish line.

The height of the Dragon was adjusted for each Dragon-trained subject just prior to the tracking trial. Since the TOW was difficult to adjust quickly, an assortment of pads was used to compensate for differences in the subjects' kneeling heights. The subjects were allowed to remove their helmets if they thought the helmets would interfere with good tracking.

At the conclusion of the 1-minute interval, the tracking cameras were turned on and the tracking cart started. The stationary target board and the appropriate trial identifiers had been filmed with both cameras between trials, so the subjects had only to concentrate on tracking the moving target. They were told to maintain a precise aim throughout the trial. When the target cart stopped at the end of the track, the cameras were turned off and the cart returned to its starting position. Subjects always tracked the cart from right to left.

After the tracking task was completed, each pair of subjects filled out questionnaires (Appendix C) to determine their reactions to the loads they had just carried and if the loads had any effect on tracking. After completing the questionnaires, the subjects were free to relax for 3 hours until their next portage task.

Phase 3: 300-Meter Carries

Except for the increase in portage distance, the procedures followed during Phase 3 were identical to those in Phase 2. The same loads (1 through 8) were carried and every subject carried each load once. Times were taken at points 150 and 75 meters from the finish line and at the finish line. The order in which the subjects carried the loads is shown in Appendix B.

Phase 4: 600-Meter Carries

Phase 4 differed from Phases 2 and 3 in increased distance. Time constraints allowed for only one trial for each subject instead of eight, and the particular load carried for that single trial was randomly determined from among Loads 1 through 4 only.

The subjects traversed the course in groups of four, and intermediate times were taken at points 450, 300, 150, and 75 meters from the end of the course. The usual post-portage questionnaires were completed at the end of the trial. There was no tracking task during Phase 4. (Appendix B lists the subject and load assignments.)

Phase 5: Supplementary 150-Meter Carries

Following the completion of Phases 1 through 4, several configurations of the Dragon IST and PLTOW mock-ups were investigated (Loads 9 through 13). Each subject carried Loads 12 and 13 and one of the remaining three (9, 10, or 11). The procedures used for this phase were the same as Phase 2. (Appendix B lists the order in which the supplementary loads were carried.)

Rested Tracking Trials

The subjects performed the standard tracking task without having first carried a load three times during the study: twice during Phase 2, and once during Phase 5. These rested tracking trials provided a baseline measure of tracking skills against which post-portage tracking could be compared.

DATA REDUCTION

Portage Times

Total and intermediate portage times were collected for each portage trial. These times were converted into portage paces, in meters-per-second, and mean and standard deviation paces were calculated across selected categories for further analysis.

Questionnaire Data

Means and standard deviations of the subjects' ratings were calculated for further analysis.

Tracking Data

The tracking films were rear-projected onto a digitizing screen by a Vanguard Model C-7D motion analyzer. The output of the digitizer, a Numonics Model 1224-113 electronic graphics calculator, was sent to a Hewlett-Packard 9830A computer which converted the digitizer measurements in inches to aiming errors in mils. The data were stored on cassettes for further analysis. The resolution of the digitizer was 0.01 inches (0.047 mils). Ten seconds (or 120 frames) of the film were digitized for each tracking trial. The 10-second period began when the cart passed a fixed post visible from the tracking area.

Standard deviations in azimuth and elevation were calculated for each 10-second section of film. The raw scores were averaged across selected categories in the data analysis.

RESULTS

Portage Pace Data

Portage pace was the basic measure of portability for this study. The mean paces and standard deviations for the loads carried in Phases 2 and 3 (150- and 300-meter carries) are shown in Table 5. The 300-meter pace was slower for each load than the 150-meter pace, and the paces were well-ordered by loads over distances.

The results of a loads-by-distance-by-subjects analysis of variance performed on the pace data are contained in Table 6. The results of the analysis confirm that both loads and portage distance had a significant[1] effect on pace. There was no significant interaction between the two independent variables.

The mean paces for both distances were averaged for each load, yielding a set of grand means. Tukey's test for pairwise comparisons of sample means was conducted to determine which specific pairs of grand means differed significantly. The critical value by which each pair had to differ to

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[1]Results were considered statistically significant only if $p < .01$.

TABLE 5

Portage Pace By Loads and Distances
(Meters/Second)

		Load 1	Load 2	Load 3	Load 4	Load 5[a]	Load 7[a]
Phase 2: 150 meters	Mean:	2.60	2.37	2.79	2.61	2.19	1.91
	SD:	0.28	0.33	0.38	0.29	0.30	0.20
Phase 3: 300 meters	Mean:	2.32	2.12	2.45	2.33	2.00	1.72
	SD:	0.32	0.27	0.33	0.31	0.22	0.12

[a]Loads 5 and 6 were the front and rear positions on a stretcher-carried load, as were Loads 7 and 8. Since the rear position of a stretcher must be carried at the same pace as the front, the data from Loads 6 and 8 have been omitted from Table 5.

TABLE 6

Analysis of Variance of the Portage Pace Data

Source of Variance	SS	df	ms	F	p
Total	52.18	319	-	-	-
Subjects	12.79	19	-	-	-
Loads	25.19	7	3.600	108.46	<.001
Portage Distances	4.53	1	4.530	136.48	<.001
Loads X Distances	0.21	7	0.030	0.90	n.s.
Residual	9.46	285	0.033	-	-

achieve statistical significance at the .01 level was found to be 0.17 meters-per-second. The results of the Tukey test revealed Loads 1, 3, and 4 were carried significantly faster than Loads 2 and 5; and Load 7 was carried more slowly than any of the others. Table 7 contains these results.

TABLE 7

Tukey's Test of the Portage Pace Data[a]

Load Number	3	4	1	2	5	7
3	----			****	****	****
4		----		****	****	****
1			----	****	****	****
2				----		****
5					----	****
7						----
Grand Mean: (M/Sec)	2.62	2.47	2.46	2.25	2.10	1.82

[a]Asterisks indicate which pairs of loads differed significantly.

A Scheffe's S test was conducted to examine the difference between individual and stretcher loads. The same critical value of 0.17 meters-per-second was necessary for the grand means of the individually carried loads to differ significantly from the grand means of the stretcher-carried loads. The grouped, grand-mean paces for the individual and stretcher loads were 2.31 and 1.86 meters-per-second: a difference of 0.45 meters-per-second, more than twice the critical value. The Scheffe's S test results show that stretcher loads were carried significantly more slowly than individual loads.

Figure 6 is a graph of the pace data from Table 5 plotted as a function of the weight of the load. For stretcher loads, the total weight was divided by two to approximate the load carried by each subject. The graph reveals an apparent relationship between the weight of the load and the pace at which that load was carried; i.e., the heavier the load, the slower the pace. A Pearson Product-Moment correlation coefficient of +.896 showed the relationship was significant at the .01 level ($t = 4.015$, $df = 4$).

The mean pace, for Loads 1 through 4 combined, for each course segment is shown in Figure 7. Two main effects are apparent from the figure: the mean pace was slower on the steeper segments of the course, especially on the final 75 meters, and the mean pace was reduced for the longer carries. For example, the pace for each segment of the 600-meter course was slower than the pace for the corresponding segment of the 300-meter course. This effect was probably caused by the subjects' selecting a slower pace to

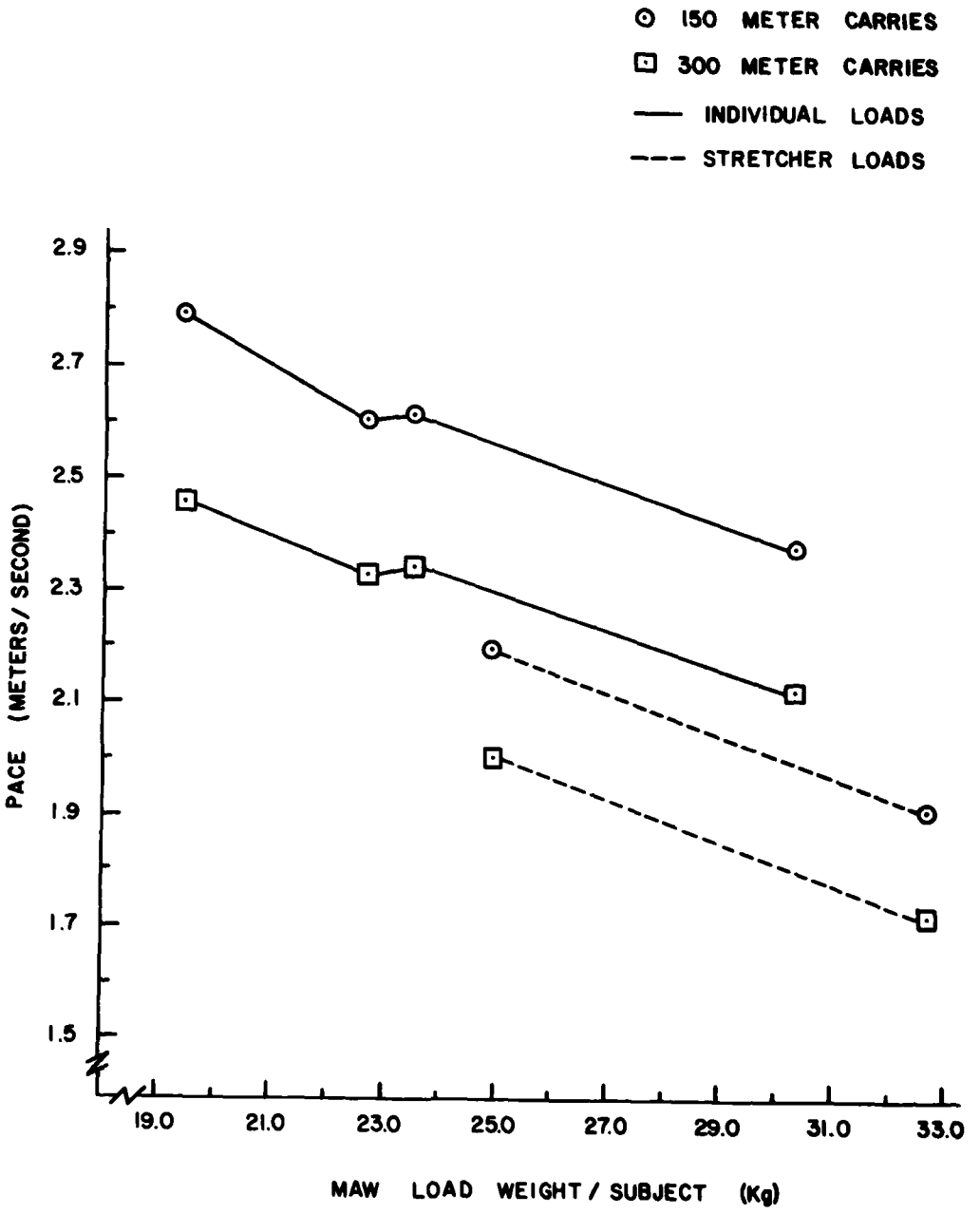

Figure 6. Portage pace as a function of load weight.

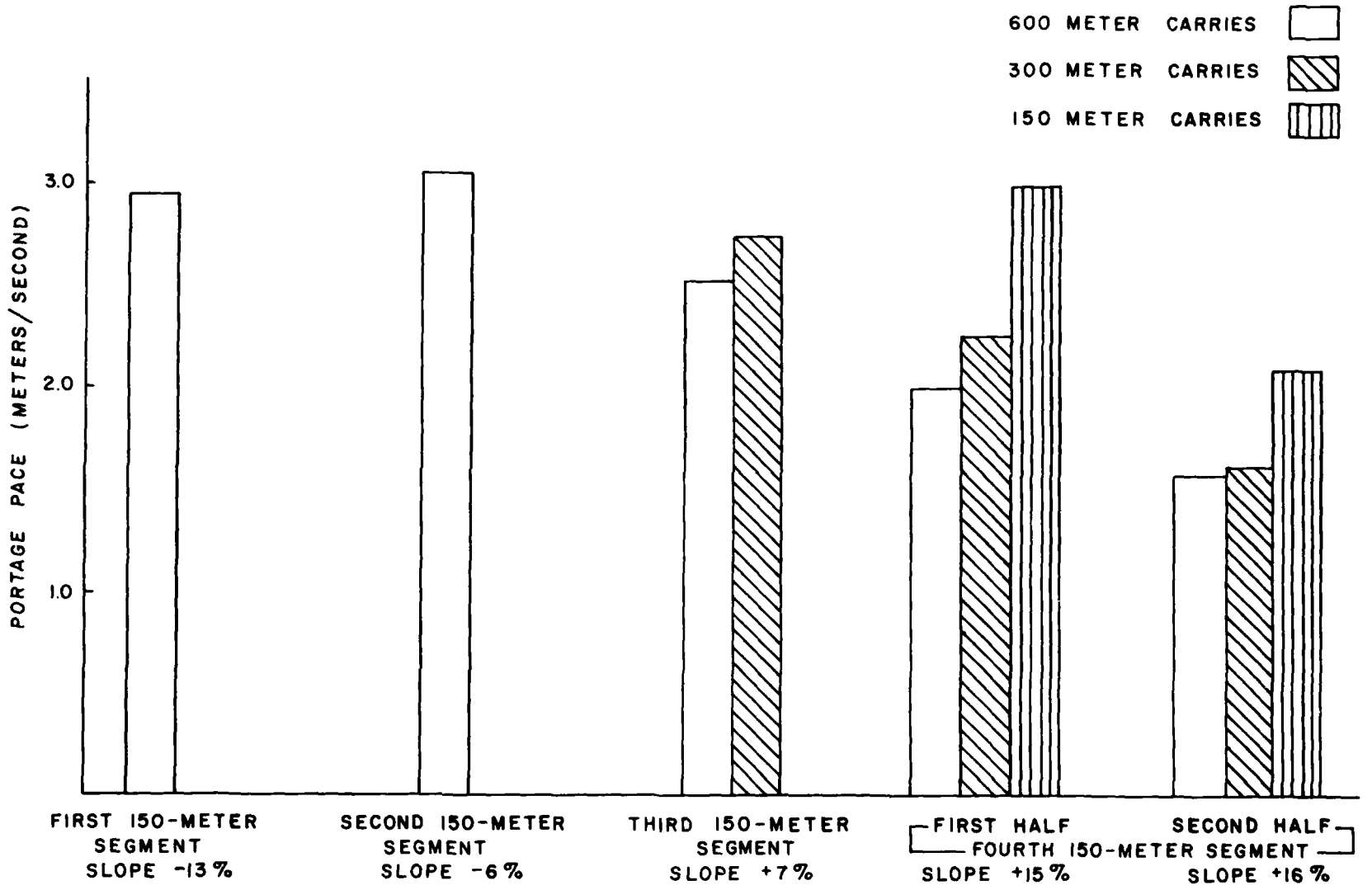

Figure 7. Portage pace as a function of course segment.

conserve energy during a longer carry, although increasing fatigue during the carry may have been a contributing factor.

Figure 8 is a graph of the mean paces for the 600-meter carries, plotted as a function of load weight. The graph shows the relationship between load weight and pace was linear up to MAW weights as heavy as 30 kg (67 pounds). The linear relationship suggests that the subjects were not overloaded by even the heaviest load, given a portage distance of 600 meters or less. The data contain no information, however, on how close the subjects were to their maximum possible load. Included in Figure 8 is the 600-meter pace for subjects carrying only their basic combat gear (i.e., a MAW load of 0 kg).

Loads 1, 2, 3, 4, 5, and 7 were ranked by pace for each timed segment of the three courses. These data are shown in Table 8. The rankings remained substantially the same regardless of course segment: Load 3 was consistently the most rapidly carried load, followed by Loads 4, 1, and 2. The slowest paces were with the two stretcher loads.

The loads tested during Phase 5 were variations on Loads 1 through 8. For instance, Loads 9 and 10 were identical to Loads 7 and 8, except the handles of the stretchers were equipped with straps to relieve some of the stress on the hands. Table 9 contains the portage paces for the four pairs of subjects who carried both Loads 7 and 8 and Loads 9 and 10. A t-test for related means revealed no significant difference between the paces for the stretcher with straps and the stretcher without straps ($t = 1.01$, $df = 3$). Some of the subjects said the straps relieved the strain on their hands by distributing part of the weight to the shoulders, particularly for those who carried the front end of the stretcher (Load 9). One subject complained the strap made the load too heavy on his neck.

Load 11 was a rearrangement of the components in Load 2 to reduce the choking caused by the criss-crossed straps of the Dragon IST round and tripod. In this load only one component (the round) was slung from the subject's shoulder; the tripod was mounted with the night sight on the pack frame. A t-test for related means conducted on the data in Table 10 revealed, however, that no significant change in pace had resulted from the rearrangement ($t = 2.19$, $df = 3$).

During Phase 5 the components of Stretcher Loads 7 and 8 were divided into two individually carried loads, designated Loads 12 and 13, weighing 33 and 30 kg (72 and 66 pounds) respectively. The pace performance data contained in Table 11 is the basis for the loads-by-subjects analysis of variance in Table 12. Results of the analysis showed that loads had a significant effect on pace. Tukey's test for pairwise comparisons yields a critical value of 0.22 meters-per-second, which means the stretcher load was carried significantly slower than either of the two individually carried loads.

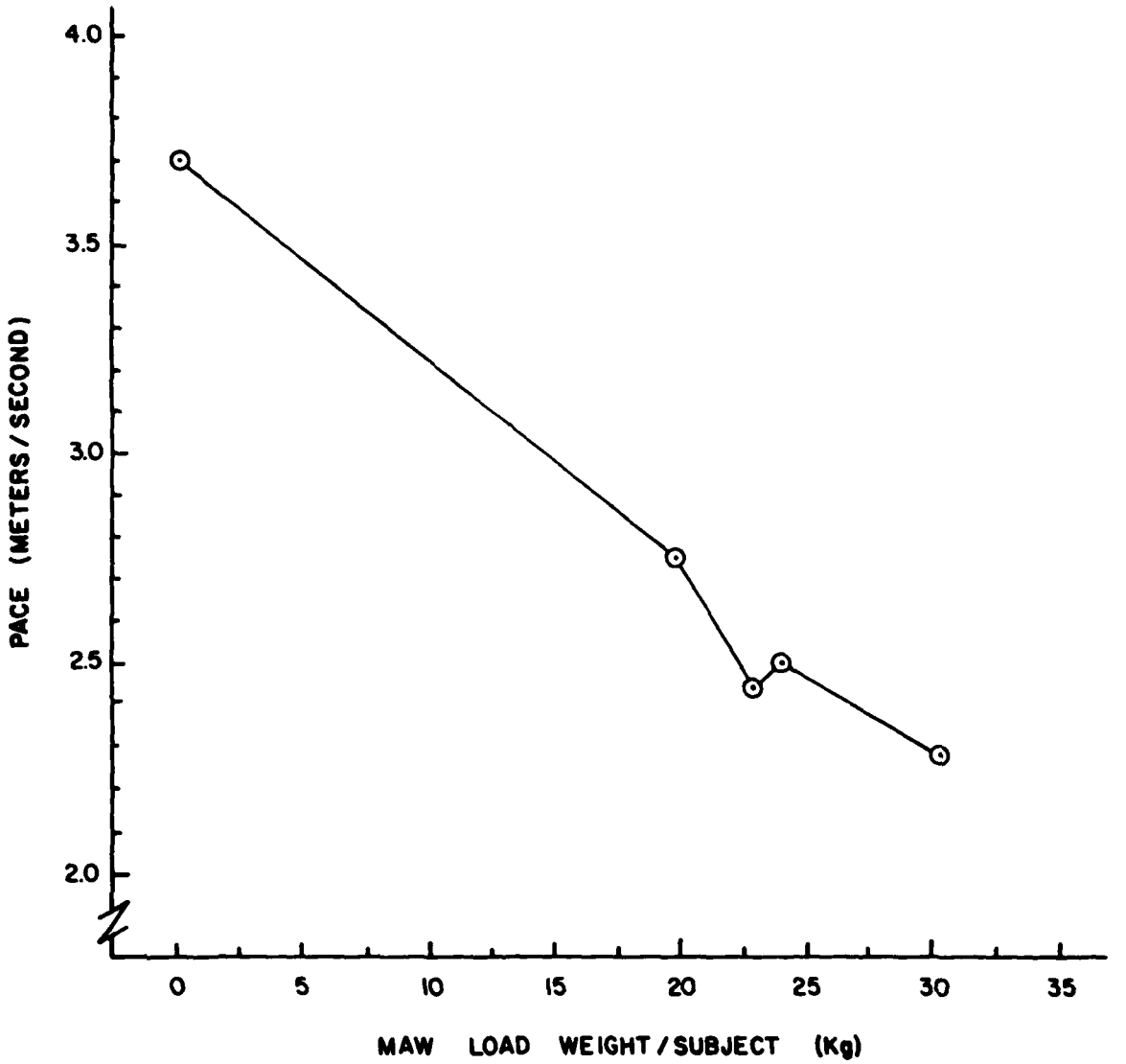

Figure 8. Portage pace as a function of load weight for the 600-meter carries.

TABLE 8

Portage Pace Rankings of Loads By Course Segment

Portage Distance	150 Meters		300 Meters			600 Meters				
Portage Segment (Meters from finish)	75 to 0	150 to 75	75 to 0	150 to 75	300 to 150	75 to 0	150 to 75	300 to 150	450 to 300	600 to 450
Rank: 1 (fastest pace):	3	3	3	3	3	3	3	3	3	3
2 :	4	1	1	1	4	4	4	4	4	1
3 :	1	4	4	4	1	1	1	1	1	4
4 :	2	2	5	2	2	2	2	2	2	2
5 :	5	5	2	5	5	Not applicable				
6 (slowest pace):	7	7	7	7	7	Not applicable				

TABLE 9

Portage Pace of Stretcher Loads 7(8) and 9(10)

Subject Pair		Mean Pace (M/Sec)	
Front	Rear	Load 7(8)	Load 9(10)
#7	#2	1.95	2.08
#11	#19	2.03	2.27
#14	#6	1.65	1.65
#18	#21	2.46	2.34
	Mean:	2.02	2.09
	SD:	0.33	0.31

TABLE 10

Portage Pace of Loads 2 and 11
(Meters/Second)

Subject Number	Load 2	Load 11
4	2.17	2.03
10	2.27	2.24
12	2.54	2.42
17	1.81	1.58
Mean:	2.20	2.07
SD:	0.30	0.36

TABLE 11

Mean Portage Paces of Loads 7(8), 12, and 13
(Meters/Second)

	Load 7(8)	Load 12	Load 13
Mean:	1.91	2.21	2.18
SD:	0.20	0.31	0.44

TABLE 12

Analysis of Variance of the Portage Pace Data of
Loads 7(8), 12, and 13

Source of Variance	SS	df	ms	F	p
Total	7.36	59	-	-	-
Subjects	4.36	19	-	-	-
Loads	1.08	2	0.540	10.59	<.001
Error	1.92	38	0.051	-	-

Tracking Data

The tracking standard deviations in azimuth and elevation for subjects using the TOW and Dragon tracking devices are summarized in Table 13. Tracking trials followed carries of three different distances: 0 meters (rested-tracking trials), 150 meters, and 300 meters. The Dragon tracking errors were roughly five times as great as the TOW errors in azimuth, regardless of the distance of the prior carry. The Dragon errors exceeded the TOW's even more in elevation. The rested trials resulted in tracking errors of about two-thirds the magnitude of the errors from the 150- and 300-meter trials for both the TOW and Dragon.

Tables 14 and 15 contain the results of two-factor (one between-subjects factor, one within) analyses of variance performed on the data summarized in Table 13.[2] The results show the Dragon tracking errors were significantly greater than those of the TOW; and that the length of the

[2]Missing data (two azimuth, two elevation) were estimated for the analysis of variance by taking the mean of the appropriate row and column means. This procedure is conservative and tends to reduce differences between conditions.

TABLE 13

Standard Deviation Tracking Errors
(Mils)

Direction	Tracker	Rested (0 Meters)	After 150 Meters	After 300 Meters
Azimuth	Dragon	1.45	2.29	2.53
	TOW	0.31	0.55	0.48
Elevation	Dragon	0.89	1.64	1.86
	TOW	0.13	0.25	0.16

TABLE 14

Analysis of Variance of the Azimuth Tracking Data By
Distance and Device

Source of Variance	SS	df	ms	F	p
Total	76.18	59	-	-	-
Between Subjects	58.53	19	-	-	-
Tracking Device	40.30	1	40.30	134.33	<.001
Error	5.42	18	0.30	-	-
Within Subjects	17.65	40	-	-	-
Distance	4.63	2	2.32	7.73	<.005
Distance X Device	2.12	2	1.06	3.53	n.s.
Error	10.90	36	0.30	-	-

TABLE 15

Analysis of Variance of the Elevation Tracking Data

Source of Variance	SS	df	ms	F	p
Total	48.38	59	-	-	-
Between Subjects	36.10	19	-	-	-
Tracking Device	24.93	1	24.93	40.20	<.001
Error	11.17	18	0.62	-	-
Within Subjects	12.28	40	-	-	-
Distance	3.03	2	1.52	8.00	<.005
Distance X Device	2.24	2	1.12	5.89	<.005
Error	7.01	36	0.19	-	-

preceding carry had a significant effect on tracking. The rested-tracking trials yielded the smallest errors.

The results of the analysis of the elevation data closely resemble those of the azimuth data, except there was a significant interaction between tracking device and portage distance for the elevation data. The TOW tracking was paradoxically better after the 300-meter carries than after the 150-meter carries.

The effects different loads had on tracking errors were investigated with a pair of three-factor (one between, two within) analyses of variance. Rested-tracking data were not included in these analyses because no loads could be carried before rested trials. The results (Tables 16 and 17) show that the only significant effect on either azimuth or elevation tracking was that of the tracking device. Tracking was more accurate with the TOW than with the Dragon. Tracking errors were not affected by the type of load or the distance it was carried.

TABLE 16

Analysis of Variance of the Azimuth Tracking Data By Load, Distance, and Device

Source of Variance	SS	df	ms	F	p
Total	708.69	319	-	-	-
Between Subjects	423.73	19	-	-	-
Tracking Device	285.06	1	285.06	37.00	<.001
Error	138.67	18	7.70	-	-
Within Subjects	284.96	300	-	-	-
Distance	0.56	1	0.56	0.15	n.s.
Load	2.06	7	0.29	0.41	n.s.
Device X Distance	2.00	1	2.00	0.53	n.s.
Device X Load	6.33	7	0.90	1.29	n.s.
Distance X Load	3.81	7	0.54	0.64	n.s.
Dev. X Dist. X Load	8.73	7	1.25	1.49	n.s.
Error 1	67.89	18	3.77	-	-
Error 2	87.59	126	0.70	-	-
Error 3	105.99	126	0.84	-	-

TABLE 17

Analysis of Variance of the Elevation Tracking Data

Source of Variance	SS	df	ms	F	p
Total	454.86	319	-	-	-
Between Subjects	299.69	19	-	-	-
Tracking Device	191.09	1	191.09	31.69	<.001
Error	108.60	18	6.03	-	-
Within Subjects	155.17	300	-	-	-
Distance	0.32	1	0.32	0.18	n.s.
Load	1.41	7	0.20	0.54	n.s.
Device X Distance	1.86	1	1.86	3.44	n.s.
Device X Load	1.09	7	0.16	0.09	n.s.
Distance X Load	2.71	7	0.39	1.05	n.s.
Dev. X Dist. X Load	2.93	7	0.42	0.78	n.s.
Error 1	31.05	18	1.73	-	-
Error 2	46.25	126	0.37	-	-
Error 3	67.55	126	0.54	-	-

Questionnaire Data

The questionnaire completed by each subject following every portage trial (Appendix C) consisted of two types of questions: rating questions and complaints. The rating questions required the subject to state his opinion about the preceding trial by circling a number corresponding to an adjective or phrase that most agreed with his opinion. The complaints, on the other hand, could not be easily analyzed because of the nominal character of the data. The subject merely checked those complaints that applied to the previous portage. The lack of a check mark for a complaint could mean a variety of things: the subject didn't feel the complaint applied; the complaint applied, but only a little; or perhaps the subject missed that complaint altogether. These uncertainties prevent any statistical analysis, so the complaint data will merely be reported in Appendix D.

Analyses of variance were conducted on the rating questions and the details are included in Appendix D. Table 18 provides a summary of the findings of the 11 analyses.

A series of Tukey's tests was performed to determine which pairs of loads had significantly different ratings. The results are summarized in Table 19.

In general, Loads 3 and 4 were rated the most favorable loads, while Loads 2, 7, and 8 were the least favorably rated.

Note: To read Table 19, insert the appropriate row and column numbers and the comparison indicated by the letter in the intersection of that row and column into the following sentence: "Load (row #) was significantly (comparison) than Load (column #)." For example, Load 7 was significantly more tiring than Load 3.

TABLE 18

Significant Effects On Subjective Ratings

Rating Values		Significant Effects ($p<.01$)*		
Rating of 1	Rating of 7	Loads	Distances	Interaction
Not Tired at All	Extremely Tired	***	***	-
Very Easy to Carry	Very Hard to Carry	***	***	-
No Trouble at All	Great Deal of Trouble	***	***	-
Compact	Bulky	***	-	-
Heavy	Light	***	-	-
Comfortable	Uncomfortable	***	***	-
Balanced	Unbalanced	***	***	***
Gear Stays Put	Gear Shifts	***	***	-
Stable	Unstable	***	***	-
Manageable	Unmanageable	-	***	***
Made Tracking Worse	Made Tracking Better	-	-	-

*Asterisks mean that the indicated variable had a significant effect on the given rating scale.

TABLE 19

Tukey's Test Results of Questionnaire Data

	MAW Loads							
	1	2	3	4	5	6	7	8
1							C	BE
2			abdfg	bdf	g	ag		h
3		ABDFG			AB	B	ABCE	BCE
4		BDF					BC	BC
5		G	ab			a		
6		AG	b		A		A	
7	c		abce	bc		a		
8	be	H	bce	bc				

KEY:

A: less tiring	a: more tiring
B: easier to carry	b: harder to carry
C: less trouble	c: more trouble
D: less bulky	d: bulkier
E: lighter	e: heavier
F: more comfortable	f: less comfortable
G: more balanced	g: less balanced
H: less prone to shifting	h: more prone to shifting
J: more stable	j: less stable
K: more manageable	k: less manageable

DISCUSSION

Portage

The maximum load a soldier can carry for extended periods of time is 30 to 40 percent of the porter's body weight (6). For the average American soldier (8) weighing 71 kg (157 lbs), the percentages are from 21 to 28 kg (47 to 63 lbs). Since the basic combat load configured in this study weighs 18 kg (40 lbs) and the Dragon round and sight weigh 15 kg (32 lbs), the total load for the Dragon gunner is 33 kg (72 lbs). It is beyond the range of weights for extended portability.

A weapon that can penetrate armor too thick for the Dragon may weigh more and would be too heavy to be carried by light infantry. This study was to determine if mechanized infantry could carry heavier weapons and still operate effectively since their marching distances are much shorter. Soldiers in the light infantry march for tens of kilometers and carry all of their necessary fighting and existence equipment. Most of the troop movements in the mechanized infantry are by vehicles and the troops are required to carry their fighting equipment only a few hundred meters.

The two weapons chosen for the portage task, the Dragon IST and the PLTOW, both weigh more than the current Dragon and represent the kinds of weights that might be required for an IMAAWS for the mech infantry. The Dragon IST weighed a total of 29 kg (64 lbs), and the PLTOW a total of 63 kg (138 lbs). No attempt was made to have either of the systems carried by a single individual, because they are crew-served weapons. A single soldier could carry an operational Dragon IST in one load only if the tripod were left behind. (This situation was represented by MAW Load 4.)

The results of the portage pace data show that the MAW loads chosen for this study could be carried by the mech infantry at least 600 meters. The portage pace decreased as the weight of the load increased, but the relationship remained linear throughout the range of weights and distances tested. The mean portage pace for the load would have plummeted below the value predicted by the linear function if any of the subjects had great difficulty in carrying a given load. Since no such portage failures occurred, it was concluded that MAW load weights of at least 34 kg (75 lbs), representing subsets of generic crew-served IMAAWS, can be carried by soldiers over the relatively short distances required by the mech infantry.

Portage time and manpower penalties incurred by the carrying of extra rounds are shown in Tables 20 and 21. These tables contain hypothetical data derived from combinations of the data from some of the subset loads. Generally, these hypothetical data show that the cost of extra rounds is one of manpower rather than of time.

TABLE 20

Load Combinations of the Dragon IST

Rounds	Tripod	Carriers	Time (150 Meters) (Seconds)	Loads Used
1	no	1	58	No. 4
1	yes	1	65	No. 2
2	yes	2	58	Nos. 3 & 4
3	yes	2	65	Nos. 1 & 2

TABLE 21

Load Combinations of the PLTOW

Rounds	Stretcher	Carriers	Time (150 Meters) (Seconds)	Loads Used
1	no	2	72	Nos. 12 & 13
1	yes	2	79	Nos. 7 & 8
3	yes	4	79	Nos. 5, 6, 7 & 8

Tracking

Load weight is not the only important variable affecting portability. Even if soldiers can carry a weapon system to its firing position successfully, they may be too tired to operate the weapon effectively. The IMAAWS gunner must be able to aim accurately at a target and, if the weapon is a guided system, track it precisely. We chose a tracking task for a test of the effects of portage because tracking is generally more difficult than aiming.

There was reason to believe that portage would have only a short-time effect on tracking accuracy. Torre (7) found a decrement in tracking ability when the subjects tracked a moving target very shortly after portage. However, Dousa and Brainerd (1) found no adverse effects on tracking when their subjects tracked a moving target with the viscously damped tracking systems. Since the subjects in the latter study had more time to recover from the effects of portage before tracking, it seemed that the decrement was strongly affected by the length of time between portage and tracking. In realistic scenarios, this delay should be related to the length of time needed to ready a given weapon system for firing. In the Torre study, the set-up time for weapons was similar to that of the Viper, so subjects could be ready to operate the weapon within 15 seconds. In the Dousa and Brainerd test, a viscously damped tracking system had to be set up before tracking

could begin. This task took 1-1/2 to 3 minutes and was enough time for the soldiers to recover from the portage.

There is no fixed IMAAWS design or fixed set-up time. A 1-minute time was arbitrarily used as the delay before tracking because (a) it fell between the delays used in the studies mentioned, and (b) the effects of delays of that length had not been previously studied.

The weapon systems chosen for the tracking task, Dragon and TOW, represent two possible types of tracking mounts for a generic IMAAWS; a bipod mount and a viscously damped mount.

The results of the tracking data showed two significant effects: (a) tracking accuracy was worse after portage than before, implying that the subjects had not yet recovered from the portage task by the time they were required to track, and (b) tracking with the viscously damped system (TOW) was better than with the bipod-mounted system (Dragon).

The reason for the TOW's superiority in tracking is probably due to the viscous damping and the fact that the tripod supports the weapon's weight. The Dragon is partly supported by the gunner's shoulder which is not a firm base when the soldier is tired from portage.

Two effects that were not found in the data were loads and distances. The degree to which tracking accuracy worsened after portage was not affected by the type or weight of the load or the distance it was carried. The conclusion was that these effects did not appear because the subjects paced themselves. Rather than start each portage trial at the fastest possible pace, they adjusted their speed according to the known distance and relative weights of the loads. Hughes and Goldman (3) found, "...men working hard tend to adjust their work level to work at energy expenditures of 425 kcal/hr $\pm$10%, regardless of the terrain or the load carried." If energy expenditure during portage is a function of subject weight, load weight, terrain, grade, and velocity, as Goldman and others (2,5) have postulated, it can be concluded that porters will keep their total energy constant regardless of the distance or time that a load is carried, since velocity is a function of distance and time. The subjects knew the distance the load was to be carried and quickly became familiar with the weight of the MAW loads. They then set their portage paces so they would have enough strength to finish the carry. In other words, they adjusted their energy usage. They completed each portage trial using the same amount of energy and performed the tracking task under the same levels of fatigue, so no changes in tracking accuracy occurred due to loads or portage distance.

Load Configuration

Minor variations in the configurations of loads (the restructuring of Load 2 into Load 11 and the addition of straps to Loads 7 and 8) did not significantly affect pace, even though the subjects commented that the reconfiguration was an improvement. For example, subjects rated Load 11 as less bulky (a mean rating of 5.25 compared to 6.25), less uncomfortable (4.25) to 5.50), and more balanced (3.75 to 5.00) than Load 2; but Load 11

was not carried significantly faster. The addition of shoulder straps to Loads 7 and 8 resulted in Loads 9 and 10 being rated less tiring (5.50 to 6.50) and less heavy (4.37 to 5.25), but there was no significant change in portage pace. If these loads had been compared for portability on an obstacle course the minor changes in configuration might have affected pace, but this effect was not found on the marching course.

On the other hand, larger alterations in load configuration resulted in changes in portage pace. The results show that stretchers are less portable than individually carried loads of the same weight. This decrement was about four-tenths of a meter per second (see Figure 6).

Loads 12 and 13 were individually carried versions of Loads 7 and 8. Both individual loads had faster mean paces than the stretcher (Table 11), although the difference was significant only with Load 12. (Time was lost when some subjects stopped to shift Load 13.) Even though the individual loads were carried faster, subjects were inconsistent in their ratings of those loads versus the stretcher. Loads 12 and 13 were rated lighter (4.55 to 5.10); but on most other scales the stretcher received the better ratings. It was considered less bulky (4.93 to 5.57), less uncomfortable (4.73 to 5.30), more balanced (3.80 to 5.50), more manageable (3.88 to 4.78), more stable (3.58 to 4.98), and less likely to have the gear shift (2.90 to 4.55) than the individual loads. The fact that the stretcher loads were firmly strapped to the stretcher may have inflated the ratings somewhat.

CONCLUSIONS

1. The MAW gunner can carry weapon systems heavier than the Dragon for the short distances required by the mechanized infantry.

2. Portage pace decreases as load weight increases.

3. Tracking after portage was worse than rested tracking.

4. Tracking accuracy was not related to the load or the distance.

5. Tracking was worse with the bipod-mounted system (Dragon) than with the viscously damped system (TOW).

6. Tracking accuracy should return to normal within 5 minutes after portage.

7. Stretcher carry had no advantage over individual carry.

RECOMMENDATION

The mechanized infantry should be equipped with heavier and more effection MAWs since their portage requirements are less stringent than those of the light infantry.

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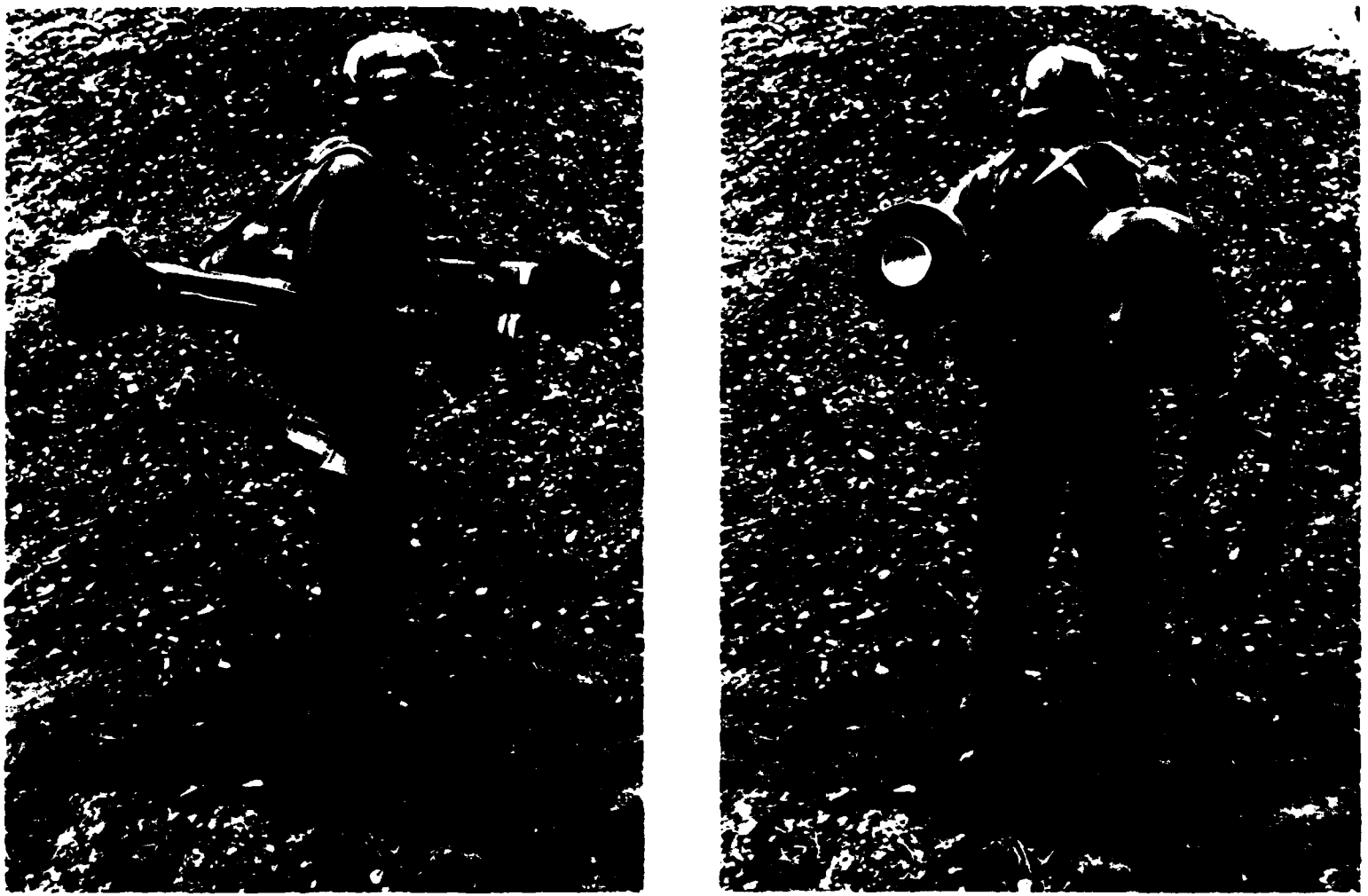
APPENDIX A

MEDIUM ANTITANK WEAPON LOAD CONFIGURATIONS



a. Side view

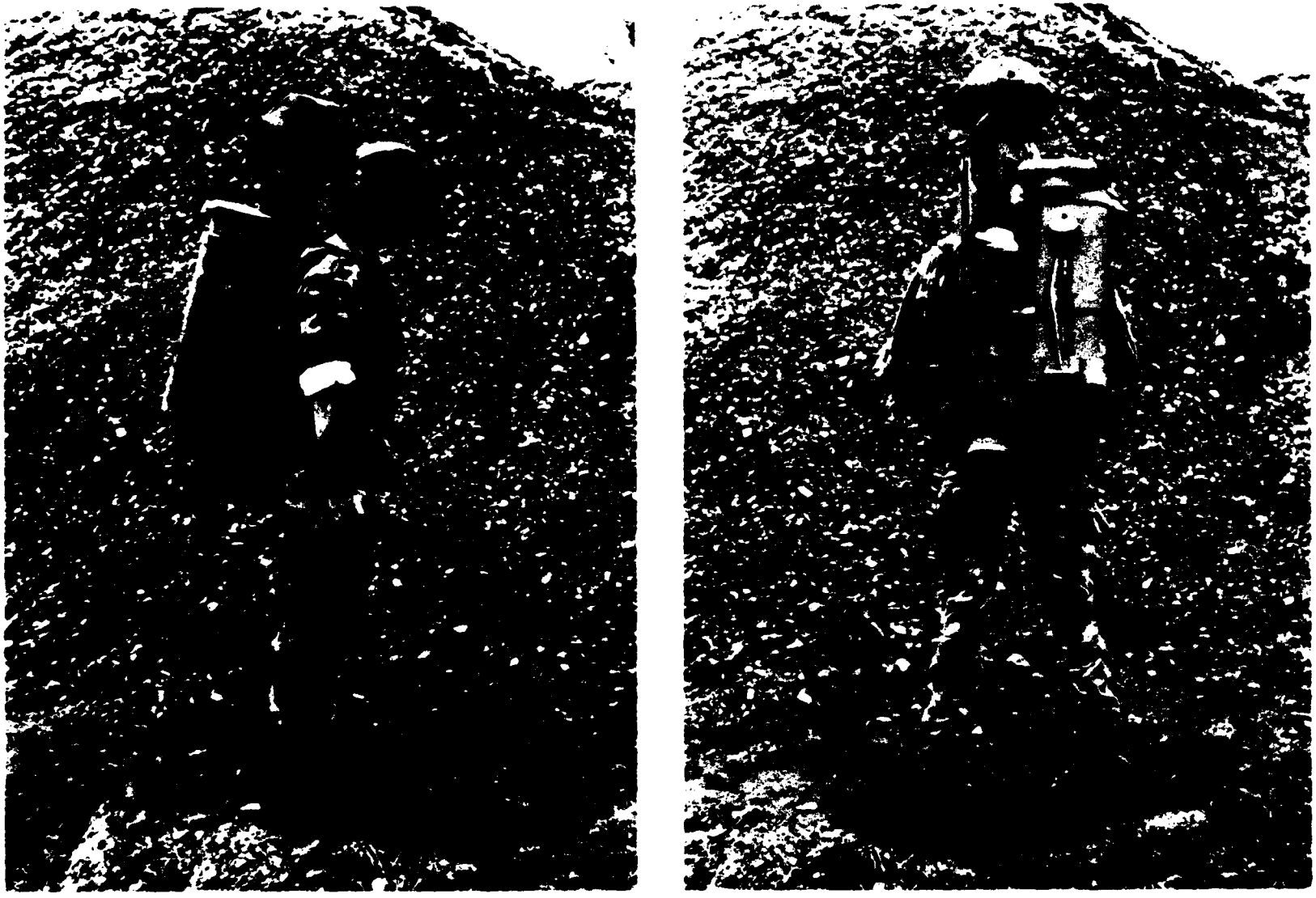
b. Back view

Figure 1A. MAW Load Number 1.

a. Side view

b. Back view

Figure 2A. MAW Load Number 2.



a. Side view

b. Back view

Figure 3A. MAW Load Number 3.

a. Side view

b. Back view

Figure 4A. MAW Load Number 4.

Figure 5A. MAW Load Numbers 5 (front) and 6 (back)--side view.

Figure 6A. MAW Load Numbers 7 (front) and 8 (back)--side view.

a. Side view

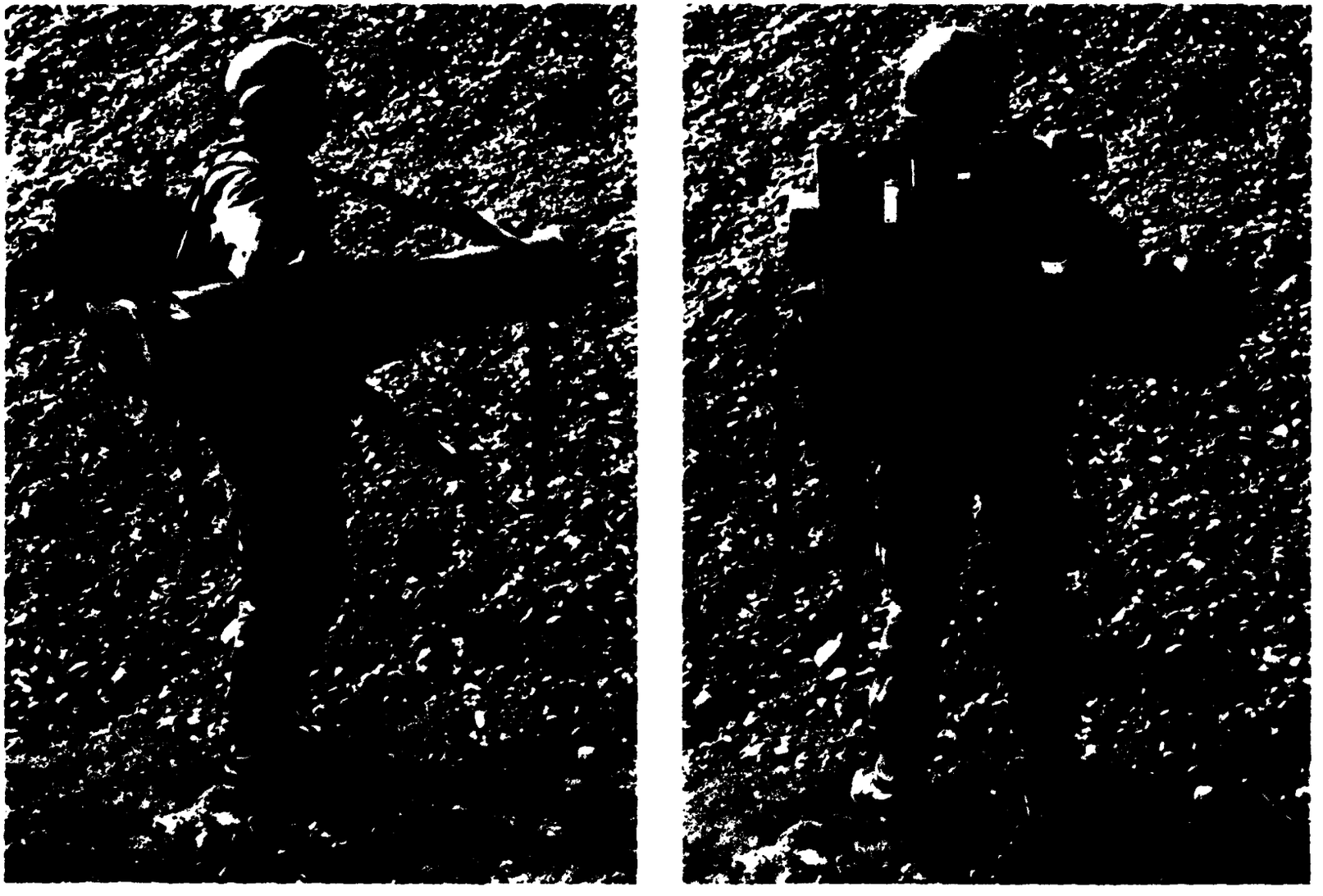
a. Back view

Figure 7A. MAW Load Number 11.

a. Side view

b. Back view

Figure 8A. MAW Load Number 12.



a. Side view

b. Back view

Figure 9A. MAW Load Number 13.

Figure 10A. Carrying MAW Load Numbers 1 (near) and 2 (far).

Figure 11A. Carrying MAW Load Number 3.

Figure 12A. Carrying MAW Load Numbers 7 and 8.

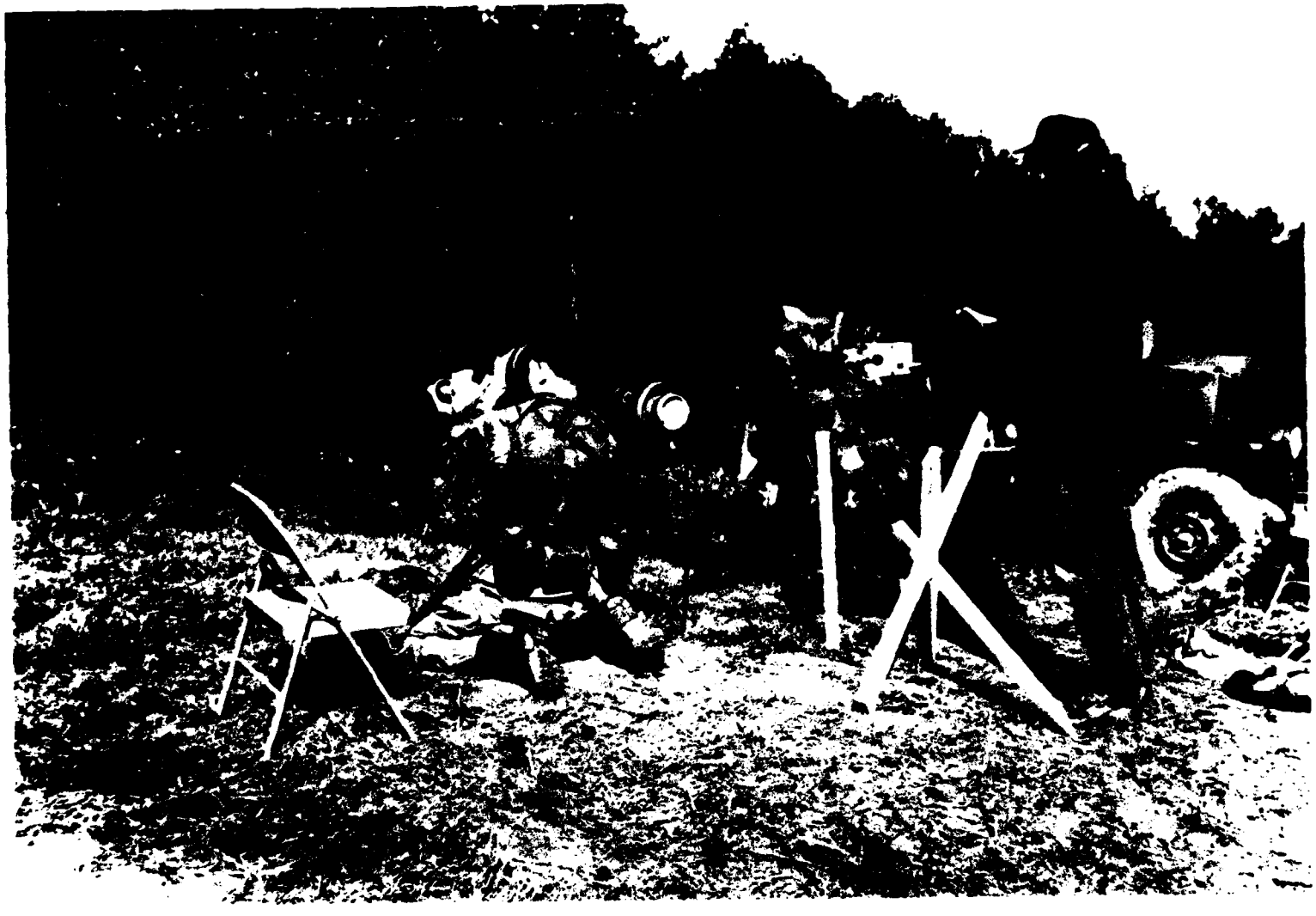


Figure 13A. Tracking station.

Figure 14A. Tracking with the Dragon.

Figure 15A. Tracking with the TOW.

APPENDIX B

PORTAGE SEQUENCE

Phase 1: 600-Meter Unloaded

Date :	11 Oct 1979 (AM)								
Subj Pair:	03/04	05/06	08/10	09/14	11/16	12/17	13/19	15/20	02/07	18/21

Phase 2: 150-Meter Carries

Date :	11 Oct 1979 (PM)									
Load Pair:	07/08	05/06	04/03	02/01	07/08	05/06	01/02	03/04	08/07	01/02
Subj Pair:	05/15	14/12	09/17	06/20	13/03	11/10	04/19	08/16	18/21	02/07
Date :	12 Oct 1979 (AM-1)									
Load Pair:	07/08	01/02	05/06	03/04	08/07	04/03	02/01	06/05	01/02	02/01
Subj Pair:	12/20	15/17	09/05	06/14	13/03	08/16	04/19	11/10	18/21	02/07
Date :	12 Oct 1979 (AM-2)									
Load Pair:	08/07	04/03	06/05	02/01	07/08	01/02	03/04	05/06	02/01	03/04
Subj Pair:	12/20	06/14	09/05	15/17	11/19	13/16	04/10	08/03	18/21	02/07
Date :	12 Oct 1979 (PM)									
Load Pair:	01/02	07/08	05/06	03/04	02/01	08/07	04/03	06/05	03/04	04/03
Subj Pair:	12/14	09/17	06/20	15/05	13/16	11/19	04/10	08/03	18/21	02/07
Date :	15 Oct 1979 (AM-1)									
Load Pair:	02/01	04/03	01/02	03/04	04/03	02/01	04/03	01/02	03/04	05/06
Subj Pair:	12/14	15/05	11/10	13/03	18/21	11/10	13/03	09/05	12/20	04/19
Date :	15 Oct 1979 (AM-2)									
Load Pair:	07/08	05/06	08/07	06/05	06/05	05/06	06/05	08/07	05/06	07/08
Subj Pair:	08/16	02/07	09/17	06/20	04/19	18/21	02/07	08/16	15/17	06/14
Date :	15 Oct 1979 (PM-1)									
Load Pair:	06/05	07/08	01/02	05/06	07/08	03/04	04/03	02/01	08/07	06/05
Subj Pair:	18/21	02/07	08/03	13/16	04/10	11/19	12/20	09/05	06/14	15/17
Date :	15 Oct 1979 (PM-2)									
Load Pair:	06/05	02/01	04/03	08/07	05/06	01/02	07/08	03/04	07/08	08/07
Subj Pair:	13/16	08/03	11/19	04/10	12/14	06/20	15/05	09/17	18/21	02/07

Phase 3: 300-Meter Carries

Date :	16 Oct 1979 (AM-1)									
Load Pair:	06/05	04/03	08/07	02/01	05/06	03/04	01/02	07/08	04/03	05/06
Subj Pair:	06/03	15/10	09/19	12/16	04/20	13/05	11/14	08/17	18/21	02/07
Date :	16 Oct 1979 (AM-2)									
Load Pair:	04/03	06/05	08/07	02/01	03/04	05/06	01/02	07/08	05/06	06/05
Subj Pair:	13/05	04/20	08/17	11/14	12/03	15/19	09/10	06/16	18/21	02/07

Phase 3: 300-Meter Carries (Continued)

Date :	16 Oct 1979 (PM-1)								
Load Pair:	04/03	08/07	02/01	06/05	03/04	07/08	05/06	01/02	06/05	07/08
Subj Pair:	12/03	06/16	09/10	15/19	11/20	04/14	13/17	08/05	18/21	02/07
Date :	16 Oct 1979 (PM-2)									
Load Pair:	07/08	05/06								
Subj Pair:	15/10	12/16								
Date :	17 Oct 1979 (AM-1)									
Load Pair:			04/03	02/01	06/05	08/07	03/04	01/02	07/08	08/07
Subj Pair:			11/20	08/05	13/17	04/14	09/19	06/03	18/21	02/07
Date :	17 Oct 1979 (AM-2)									
Load Pair:	03/04	01/02	05/06	07/08	04/03	02/01	08/07	06/05	08/07	01/02
Subj Pair:	08/17	04/20	11/14	13/05	09/19	06/03	15/10	12/16	18/21	02/07
Date :	17 Oct 1979 (PM-1)									
Load Pair:	03/04	07/08	04/03	08/07	06/05	01/02	05/06	02/01	01/02	02/01
Subj Pair:	06/16	12/03	08/17	13/05	11/14	15/19	09/10	04/20	18/21	02/07
Date :	17 Oct 1979 (PM-2)									
Load Pair:	03/04	05/06	07/08	01/02	04/03	06/05	02/01	08/07	02/01	03/04
Subj Pair:	04/14	08/05	11/20	13/17	06/16	09/10	15/19	12/03	18/21	02/07
Date :	18 Oct 1979 (AM-1)									
Load Pair:	06/05	09/10	03/04	07/08	01/02	04/03	02/01	08/07	03/04	04/03
Subj Pair:	08/05	06/03	15/10	09/19	12/16	04/14	13/17	11/20	18/21	02/07

Phase 4: 600-Meter Carries

Date :	18 Oct 1979 (AM-2)				
Load Group:	01/02/03/04	01/02/03/04	01/02/03/04	01/02/03/04	01/02/03/04
Subj Group:	08/05/06/03	15/10/09/19	12/16/04/14	13/17/11/20	18/21/02/07

Phase 5: Supplementary 150-Meter Carries

Date :	18 Oct 1979 (PM-1)									
Load Pair:	11/12	13/11	10/09	12/13	09/10	11/12	13/11	12/13	09/10	10/09
Subj Pair:	04/03	06/10	08/05	09/14	11/19	12/16	13/17	15/20	18/21	02/07
Date :	18 Oct 1979 (PM-2)									
Load Pair:	12/13	12/13	13/12	12/13						
Subj Pair:	04/03	08/05	09/14	11/19						
Date :	19 Oct 1979 (AM-1)									
Load Pair:					12/13	12/13	12/13	13/12	12/13	12/13
Subj Pair:					06/10	12/16	13/17	15/20	18/21	02/07

Phase 5: Supplementary 150-Meter Carries (Continued)

Date :	19 Oct 1979 (AM-2)									
Load Pair:	13/12	13/12	13/12	13/12	13/12	13/12	10/09	10/09	10/09	10/09
Subj Pair:	04/10	08/05	11/19	12/17	18/21	02/07	09/03	13/16	06/14	15/20

APPENDIX C

QUESTIONNAIRES

Participant Agreement

I, _____, having full capacity of consent, do hereby volunteer to participate in a project entitled Medium Antitank Weapon Portability Study

under the direction of Mr. Samuel T. Brainerd.

The implications of my voluntary participation, the nature, duration and purpose, the means by which it is to be conducted and the inconveniences and hazards which may reasonably be expected have been explained to me by Mr. Brainerd. I have been given an opportunity to ask questions concerning this project and any such questions have been answered to my full and complete satisfaction. I understand that I may at any time during this project revoke my consent and withdraw from the test without prejudice, however, I may be required to undergo physical examination if in the opinion of a physician such examination is necessary for my health and well being.

_____

Signature Date

I was present during the explanations referred to above as well as the volunteer's opportunity for questions and hereby witness his signature.

_____

Signature Date

DEMOGRAPHICS AND EXPERIENCE QUESTIONNAIRE

Name _____

Age _____ Height _____ Weight _____

Rank _____ Time in Service _____ Primary MOS _____ Secondary MOS _____

Are you _____ left handed or _____right handed? (Check one)

Do you wear glasses? _____always _____sometimes _____for reading _____never
(check one)

Have you had any Dragon Missile training? _____yes _____no (check one)

IF YES: Have you ever fired the trainer? _____yes _____no (check one)

How many times? _____

Did you qualify as a gunner? _____yes _____no (check one)

Qualification rating: _____

Have you ever fired a live Dragon missile? _____yes _____no (check one)

How many times? _____

Have you had any TOW Missile training? _____yes _____no (check one)

IF YES: Have you ever fired the simulator? _____yes _____no (check one)

How many times? _____

Did you qualify as a gunner? _____yes _____no (check one)

Qualification rating: _____

Have you ever fired a live TOW missile? _____yes _____no (check one)

How many times?_____

Have you ever used any other tracking devices, such as:

Modular Universal Laser Equipment (MULE) _____yes _____no (check one)

Ground Laser Locator Designator (GLLD) _____yes _____no (check one)

Others: _____ _____yes _____no (check one)

_____ _____yes _____no (check one)

_____ _____yes _____no (check one)

PORTABILITY QUESTIONNAIRE

(Please Print All Answers)

Experimenter Use Only

Name: _____

ID# : _____

Supervisor: B W Z

Run #: _____

Date: _____

Tracking System: D T

Time: _____

1. How did you feel at the end of the test course? (Circle one number.)

NOT AT ALL TIRED 1 2 3 4 5 6 7 EXTREMELY TIRED

2. How would you rate the load that you just carried with respect to its portability (ease of carry)? (Circle one number.)

VERY EASY TO CARRY 1 2 3 4 5 6 7 VERY HARD TO CARRY

3. How much trouble did you have carrying the test load over the course hills? (Circle one number.)

NO TROUBLE AT ALL 1 2 3 4 5 6 7 A GREAT DEAL OF TROUBLE

Which of the following things about the test load that you just carried or the course that you just covered caused you trouble? Place a check mark (✓) by all of the things that caused you trouble.

_____ 1. The course was too long.

_____ 2. The course was rough.

_____ 3. The course was slippery.

_____ 4. The footing was poor because of loose dirt or gravel.

_____ 5. The sharp edges of the load dug into my body.

_____ 6. The load was too heavy.

_____ 7. The load was unbalanced.

_____ 8. The straps dug into my shoulders.

_____ 9. The load flopped around and bumped against my body.

_____ 10. The load was too long.

_____ 11. The load was too short.

_____ 12. The stretcher load kept shifting or sliding around.

_____ 13. The stretcher load kept swinging.

_____ 14. It was difficult to walk uphill with the back of the stretcher.

_____ 15. It was difficult to walk uphill with the front of the stretcher.

_____ 16. It was difficult to walk downhill with the back of the stretcher.

_____ 17. It was difficult to walk downhill with the front of the stretcher.

_____ 18. The load was too wide.

4. Rate the weapon you carried today with respect to the following characteristics: (Circle one number for each row.)

	EXTREMELY	MODERATELY	SLIGHTLY	NEUTRAL	SLIGHTLY	MODERATELY	EXTREMELY	
a. COMPACT	1	2	3	4	5	6	7	BULKY
b. HEAVY	1	2	3	4	5	6	7	LIGHT
c. COMFORTABLE	1	2	3	4	5	6	7	UNCOMFORTABLE
d. BALANCED	1	2	3	4	5	6	7	UNBALANCED
e. GEAR STAYS PUT	1	2	3	4	5	6	7	GEAR MOVES AROUND
f. STABLE	1	2	3	4	5	6	7	UNSTABLE
g. MANAGEABLE	1	2	3	4	5	6	7	UNMANAGEABLE

5. How did carrying the test load affect your tracking performance? (Circle <u>one</u> number.)

				NO EFFECT			
MADE TRACKING MUCH WORSE	1	2	3	4	5	6	7	MADE TRACKING MUCH BETTER

APPENDIX D

ANALYSIS OF QUESTIONNAIRE DATA

Ratings Questions Section

Ratings: Question 1- How did you feel at the end of the test course?

Rating Scale: 1 = Not tired at all; 7 = Extremely tired

Mean Ratings (with sample size):

	150 Meters	300 Meters	600 Meters
Load 1	5.15 (20)	5.65 (20)	7.00 (5)
Load 2	5.65 (20)	5.90 (20)	6.60 (5)
Load 3	4.85 (20)	5.20 (20)	6.20 (5)
Load 4	5.25 (20)	5.75 (20)	6.20 (5)
Load 5	5.95 (20)	5.63 (19)	
Load 6	4.75 (20)	5.42 (19)	
Load 7	5.85 (20)	6.10 (20)	
Load 8	5.30 (20)	5.95 (20)	
Load 9	5.25 (8)		
Load 10	5.25 (8)		
Load 11	5.20 (5)		
Load 12	5.15 (20)		
Load 13	5.20 (20)		

Analysis of Variance Conducted On the Data Within the Box (α = .01)

Source of Variance	SS	df	ms	F	p
Total	465.8	319	-	-	-
Subjects	191.5	19	-	-	-
Loads	32.8	7	4.7	6.8	<.001
Distances	10.2	1	10.2	10.7	<.005
LxD	6.7	7	1.0	1.1	n.s.
Error L	91.1	133	0.7	-	-
Error D	18.0	19	0.9	-	-
Error LxD	115.6	133	0.9	-	-

General Comments:

Loads 3 and 6 were the least tiring.

The front ends of the stretchers (Loads 5 and 7) were more tiring than the backs (Loads 6 and 8).

Longer distance carries were more tiring than shorter distance carries.

Ratings: Question 2- How would you rate the load that you just carried with respect to its portability?

Rating Scale: 1 = Very easy to carry; 7 = Very hard to carry

Mean Ratings (with sample size):

	150 Meters	300 Meters	600 Meters
Load 1	5.05 (20)	5.20 (20)	6.20 (5)
Load 2	5.65 (20)	6.00 (20)	6.00 (5)
Load 3	4.35 (20)	4.55 (20)	4.60 (5)
Load 4	4.50 (20)	5.05 (20)	5.80 (5)
Load 5	5.60 (20)	5.79 (19)	
Load 6	5.20 (20)	5.74 (19)	
Load 7	6.05 (20)	6.20 (20)	
Load 8	5.80 (20)	6.50 (20)	
Load 9	5.13 (8)		
Load 10	5.38 (8)		
Load 11	5.20 (5)		
Load 12	5.85 (20)		
Load 13	5.80 (20)		

Analysis of Variance Conducted On the Data Within the Box (α = .01)

Source of Variance	SS	df	ms	F	p
Total	477.3	319	-	-	-
Subjects	124.7	19	-	-	-
Loads	108.4	7	15.5	14.4	<.001
Distances	10.2	1	10.2	8.5	<.01
LxD	3.3	7	0.5	1.0	n.s.
Error L	142.6	133	1.1	-	-
Error D	22.8	19	1.2	-	-
Error LxD	65.3	133	0.5	-	-

General Comments:

Loads 3 and 4 were the least hard to carry.

The longer distance carries were harder than the shorter distance carries.

Ratings: Question 3- How much trouble did you have carrying the test load over the course hills?

Rating Scale: 1 = No trouble at all; 7 = A great deal of trouble

Mean Ratings (with sample size):

	150 Meters	300 Meters	600 Meters
Load 1	4.90 (20)	5.20 (20)	6.20 (5)
Load 2	5.55 (20)	5.80 (20)	6.60 (5)
Load 3	4.60 (20)	5.10 (20)	4.60 (5)
Load 4	4.55 (20)	5.05 (20)	4.20 (5)
Load 5	5.45 (20)	5.74 (19)	
Load 6	4.85 (20)	5.74 (19)	
Load 7	5.95 (20)	6.20 (20)	
Load 8	5.40 (20)	6.25 (20)	
Load 9	5.38 (8)		
Load 10	5.25 (8)		
Load 11	5.20 (5)		
Load 12	5.50 (20)		
Load 13	5.55 (20)		

Analysis of Variance Conducted On the Data Within the Box (α = .01)

Source of Variance	SS	df	ms	F	p
Total	462.6	319	-	-	-
Subjects	168.8	19	-	-	-
Loads	61.9	7	8.8	10.4	<.001
Distances	18.5	1	18.5	16.6	<.001
LxD	4.8	7	0.7	1.3	n.s.
Error L	113.4	133	0.9	-	-
Error D	21.2	19	1.1	-	-
Error LxD	74.0	133	0.6	-	-

General Comments:

Loads 3 and 4 were the least trouble.

Loads 7 and 8 (both ends of the heavy stretcher) were the most trouble.

On the steeper course (150-meters) the front ends of the stretcher tended to be more trouble, although there was no difference on the less-steep 300-meter course.

The longer the course, the more difficult the carry.

Ratings: Question 4a- Rate the weapon you carried: compact or bulky?

Rating Scale: 1 = Extremely compact; 7 = Extremely bulky

Mean Ratings (with sample size):

	150 Meters	300 Meters	600 Meters
Load 1	4.75 (20)	4.85 (20)	6.20 (5)
Load 2	5.95 (20)	5.55 (20)	6.60 (5)
Load 3	4.25 (20)	4.30 (20)	4.60 (5)
Load 4	4.45 (20)	4.15 (20)	4.20 (5)
Load 5	4.90 (20)	4.58 (19)	
Load 6	4.55 (20)	4.84 (19)	
Load 7	5.05 (20)	5.40 (20)	
Load 8	4.80 (20)	5.30 (20)	
Load 9	5.38 (8)		
Load 10	5.25 (8)		
Load 11	5.20 (5)		
Load 12	5.45 (20)		
Load 13	5.70 (20)		

Analysis of Variance Conducted On the Data Within the Box (α = .01)

Source of Variance	SS	df	ms	F	p
Total	717.4	319	-	-	-
Subjects	275.1	19	-	-	-
Loads	66.3	7	9.5	5.3	<.001
Distances	0.1	1	0.1	0.1	n.s.
LxD	8.0	7	1.1	1.4	n.s.
Error L	236.9	133	1.8	-	-
Error D	21.6	19	1.1	-	-
Error LxD	109.2	133	0.8	-	-

General Comments:

Loads 2 and 13 were the most bulky loads.

The distance of the march did not affect ratings of bulkiness.

Ratings: Question 4b- Rate the weapon you carried: heavy or light?

Rating Scale: 1 = Extremely heavy; 7 = Extremely light

Mean Ratings (with sample size):

	150 Meters	300 Meters	600 Meters
Load 1	2.85 (20)	2.95 (20)	2.20 (5)
Load 2	2.75 (20)	2.15 (20)	1.60 (5)
Load 3	3.30 (20)	3.10 (20)	3.40 (5)
Load 4	2.60 (20)	2.85 (20)	3.40 (5)
Load 5	2.75 (20)	2.47 (19)	
Load 6	2.50 (20)	2.37 (19)	
Load 7	1.90 (20)	2.25 (20)	
Load 8	1.90 (20)	1.45 (20)	
Load 9	2.75 (8)		
Load 10	2.38 (8)		
Load 11	2.00 (5)		
Load 12	2.45 (20)		
Load 13	2.45 (20)		

Analysis of Variance Conducted On the Data Within the Box (α = .01)

Source of Variance	SS	df	ms	F	p
Total	526.0	319	-	-	-
Subjects	167.6	19	-	-	-
Loads	64.1	7	9.2	9.7	<.001
Distances	1.1	1	1.1	0.6	n.s.
LxD	8.3	7	1.2	1.3	n.s.
Error L	125.9	133	0.9	-	-
Error D	36.9	19	1.9	-	-
Error LxD	122.1	133	0.9	-	-

General Comments:

Loads 7 and 8 (the heavy stretcher) were rated the heaviest.

The distance of portage did not affect the weight ratings.

Ratings: Question 4c- Rate the weapon you carried: comfortable or uncomfortable?

Rating Scale: 1 = Extremely comfortable; 7 = Extremely uncomfortable

Mean Ratings (with sample size):

	150 Meters	300 Meters	600 Meters
Load 1	4.95 (20)	5.11 (19)	6.40 (5)
Load 2	5.30 (20)	5.55 (20)	6.00 (5)
Load 3	4.05 (20)	4.15 (20)	4.20 (5)
Load 4	4.25 (20)	4.25 (20)	4.80 (5)
Load 5	4.55 (20)	4.84 (19)	
Load 6	4.35 (20)	5.05 (19)	
Load 7	4.95 (20)	5.20 (20)	
Load 8	4.50 (20)	5.56 (20)	
Load 9	5.00 (8)		
Load 10	5.13 (8)		
Load 11	4.40 (5)		
Load 12	5.25 (20)		
Load 13	5.35 (20)		

Analysis of Variance Conducted On the Data Within the Box (α = .01)

Source of Variance	SS	df	ms	F	p
Total	542.4	319	-	-	-
Subjects	207.4	19	-	-	-
Loads	56.2	7	8.0	7.2	<.001
Distances	10.5	1	10.5	8.3	<.01
LxD	10.1	7	1.4	2.2	n.s.
Error L	147.8	133	1.1	-	-
Error D	24.0	19	1.3	-	-
Error LxD	86.4	133	0.6	-	-

General Comments:

Loads 2, 12, and 13 were rated most uncomfortable.

The longer the distance, the more uncomfortable were the loads.

Ratings: Question 4d- Rate the weapon you carried: balanced or unbalanced?

Rating Scale: 1 = Extremely balanced; 7 = Extremely unbalanced.

Mean Ratings (with sample size):

	150 Meters	300 Meters	600 Meters
Load 1	4.00 (20)	4.55 (20)	5.40 (5)
Load 2	5.25 (20)	5.25 (20)	5.40 (5)
Load 3	4.20 (20)	3.65 (20)	4.40 (5)
Load 4	4.10 (20)	4.00 (20)	4.60 (5)
Load 5	3.55 (20)	3.74 (19)	
Load 6	3.30 (20)	4.42 (19)	
Load 7	3.75 (20)	4.58 (19)	
Load 8	4.00 (20)	5.10 (20)	
Load 9	4.50 (8)		
Load 10	4.25 (8)		
Load 11	3.80 (5)		
Load 12	5.40 (20)		
Load 13	5.60 (20)		

Analysis of Variance Conducted On the Data Within the Box (α = .01)

Source of Variance	SS	df	ms	F	p
Total	669.5	319	-	-	-
Subjects	189.8	19	-	-	-
Loads	70.0	7	10.0	6.8	<.001
Distances	12.0	1	12.0	8.5	<.01
LxD	25.4	7	3.6	3.3	<.005
Error L	196.7	133	1.5	-	-
Error D	27.0	19	1.4	-	-
Error LxD	148.6	133	1.1	-	-

General Comments:

Load 2 was considered unbalanced at all distances.

Loads 12 and 13 were rated unbalanced.

Stretcher loads were rated unbalanced at 300 meters, but not at 150 meters.

Loads 3 and 4 were rated more balanced at 300 meters than at 150 meters.

Ratings: Question 4e- Rate the weapon you carried: does the gear stay put or does it move around?

Rating Scale: 1 = Gear stays put extremely; gear moves around extremely

Mean Ratings (with sample size):

	150 Meters	300 Meters	600 Meters
Load 1	3.90 (20)	4.85 (20)	5.80 (5)
Load 2	4.75 (20)	4.85 (20)	4.80 (5)
Load 3	3.80 (20)	3.65 (20)	3.80 (5)
Load 4	3.55 (20)	3.70 (20)	4.60 (5)
Load 5	4.10 (20)	4.42 (19)	
Load 6	4.05 (20)	4.84 (19)	
Load 7	3.15 (20)	4.20 (20)	
Load 8	2.65 (20)	3.68 (19)	
Load 9	3.88 (8)		
Load 10	3.50 (8)		
Load 11	4.00 (5)		
Load 12	3.80 (20)		
Load 13	5.30 (20)		

Analysis of Variance Conducted On the Data Within the Box (α = .01)

Source of Variance	*SS*	*df*	*ms*	F	p
Total	797.0	319	-	-	-
Subjects	216.8	19	-	-	-
Loads	81.9	7	11.7	5.7	<.001
Distances	22.6	1	22.6	11.4	<.005
LxD	16.3	7	2.3	2.1	n.s.
Error L	273.8	133	2.1	-	-
Error D	37.7	19	2.0	-	-
Error LxD	147.8	133	1.1	-	-

General Comments:

Load 7 was rated best in lack of gear movement; Loads 2 and 13 were worst.

Gear was perceived to move around more on the longer marches.

Ratings: Question 4f- Rate the weapon you carried: stable or unstable?

Rating Scale: 1 = Extremely stable; 7 = Extremely unstable

Mean Ratings (with sample size):

	150 Meters	300 Meters	600 Meters
Load 1	3.90 (20)	4.55 (20)	6.00 (5)
Load 2	4.65 (20)	4.85 (20)	5.40 (5)
Load 3	3.50 (20)	3.65 (20)	4.20 (5)
Load 4	3.65 (20)	3.80 (20)	4.40 (5)
Load 5	4.15 (20)	4.21 (19)	
Load 6	3.95 (20)	4.63 (19)	
Load 7	4.05 (20)	4.40 (20)	
Load 8	3.10 (20)	4.60 (20)	
Load 9	3.75 (8)		
Load 10	4.13 (8)		
Load 11	3.80 (5)		
Load 12	4.60 (20)		
Load 13	5.35 (20)		

Analysis of Variance Conducted On the Data Within the Box (α = .01)

Source of Variance	SS	df	ms	F	p
Total	677.6	319	-	-	-
Subjects	245.2	19	-	-	-
Loads	39.1	7	5.6	3.7	<.005
Distances	17.6	1	17.6	8.3	<.01
LxD	16.1	7	2.3	2.6	n.s.
Error L	201.8	133	1.5	-	-
Error D	40.2	19	2.1	-	-
Error LxD	117.5	133	0.9	-	-

General Comments:

Loads 2, 12, and 13 were rated most unstable.

Loads were rated less stable after long marches.

Ratings: Question 4g- Rate the weapon you carried: manageable or unmanageable?

Rating Scale: 1 = Extremely manageable; 7 = Extremely unmanageable

Mean Ratings (with sample size):

	150 Meters	300 Meters	600 Meters
Load 1	4.15 (20)	4.25 (20)	5.60 (5)
Load 2	4.65 (20)	4.55 (20)	5.20 (5)
Load 3	3.55 (20)	3.50 (20)	3.40 (5)
Load 4	4.15 (20)	3.75 (20)	4.60 (5)
Load 5	4.00 (20)	4.26 (19)	
Load 6	3.80 (20)	4.42 (19)	
Load 7	4.05 (20)	4.75 (20)	
Load 8	3.70 (20)	4.45 (20)	
Load 9	4.00 (8)		
Load 10	4.13 (8)		
Load 11	4.00 (5)		
Load 12	4.40 (20)		
Load 13	5.15 (20)		

Analysis of Variance Conducted On the Data Within the Box (α = .01)

Source of Variance	SS	df	ms	F	p
Total	590.2	319	-	-	-
Subjects	249.7	19	-	-	-
Loads	28.0	7	4.0	2.8	n.s.
Distances	4.3	1	4.3	2.9	<.01
LxD	12.3	7	1.8	3.1	<.005
Error L	193.0	133	1.5	-	-
Error D	27.9	19	1.5	-	-
Error LxD	75.0	133	0.6	-	-

General Comments:

Loads 3 and 4 were rated more manageable at 300 meters than at 150 meters; all other loads were either rated the same or less manageable.

Ratings: Question 5- How did carrying the test load affect your tracking performance?

Rating Scale: 1 = Made tracking much worse; 7 = Made tracking much better

Mean Ratings (with sample size):

	150 Meters	300 Meters	600 Meters
Load 1	2.84 (19)	3.30 (20)	
Load 2	2.85 (20)	2.95 (20)	Note:
Load 3	3.30 (20)	3.40 (20)	No tracking
Load 4	3.45 (20)	3.55 (20)	after
Load 5	3.53 (19)	3.47 (19)	600 meters.
Load 6	3.55 (20)	3.00 (19)	
Load 7	2.80 (20)	2.90 (20)	
Load 8	3.00 (19)	3.00 (20)	
Load 9	3.86 (7)		
Load 10	3.38 (7)		
Load 11	3.60 (5)		
Load 12	3.40 (20)		
Load 13	3.32 (19)		

Analysis of Variance Conducted On the Data Within the Box (α = .01)

Source of Variance	SS	df	ms	F	p
Total	703.5	319	-	-	-
Subjects	353.6	19	-	-	-
Loads	18.9	7	2.7	2.3	n.s.
Distances	0.0	1	0.0	0.0	n.s.
LxD	5.5	7	0.8	0.9	n.s.
Error L	155.9	133	1.2	-	-
Error D	56.3	19	3.0	-	-
Error LxD	113.1	133	0.9	-	-

General Comments:

Neither type of load nor portage distance were perceived to affect tracking performance.

Complaints Section

Which of the following things about the test load that you just carried or the course that you just covered caused you trouble? Place a check mark by all of the things that caused you trouble.

1. The course was too long.

Percent of subjects placing a check mark, by condition:

	Percent
150 meters	4
300 meters	51
Load 1	25
Load 2	28
Load 3	20
Load 4	25
Load 5	30
Load 6	33
Load 7	28
Load 8	30

Subjective Comments: The 300-meter course was considered too long by half of the subjects.

2. The course was rough.

Percent of subjects placing a check mark, by condition:

	Percent
150 meters	19
300 meters	37
Load 1	13
Load 2	23
Load 3	23
Load 4	18
Load 5	33
Load 6	20
Load 7	35
Load 8	28

Subjective Comments: Nearly twice as many subjects thought the 300-meter course was rougher than the 150-meter course, but the total number of complaints was not very high in either case.

3. The course was slippery.

Percentage of subjects placing a check mark, by condition:

	Percent
150 meters	37
300 meters	14
Load 1	23
Load 2	28
Load 3	33
Load 4	28
Load 5	28
Load 6	18
Load 7	23
Load 8	28

Subjective Comments: The 150-meter course was considered slippery more often than the 300-meter course, because of all the rain that fell during Phase 2.

4. The footing was poor.

Percent of subjects placing a check mark, by condition:

	Percent
150 meters	66
300 meters	43
Load 1	58
Load 2	53
Load 3	50
Load 4	60
Load 5	50
Load 6	53
Load 7	58
Load 8	60

Subjective Comments: More than half of the subjects considered the footing to be poor, not only because it was slippery (see last complaint), but also because of the ruts in the dirt road.

5. Sharp edges dug into my body.

Percent of subjects placing a check mark, by condition:

	Percent
150 meters	14
300 meters	18
Load 1	35
Load 2	48
Load 3	13
Load 4	20
Load 5	5
Load 6	0
Load 7	8
Load 8	0

Subjective Comments: Only Loads 1 and 2 produced many complaints.

6. The load was too heavy.

Percent of subjects placing a check mark, by condition:

	Percent
150 meters	46
300 meters	57
Load 1	30
Load 2	53
Load 3	23
Load 4	35
Load 5	55
Load 6	45
Load 7	88
Load 8	75

Subjective Comments: Almost all of the subjects felt that the 65.3 kg stretcher (Loads 7 and 8) was too heavy.

7. The load was unbalanced.

Percent of subjects placing a check mark, by condition:

	Percent
150 meters	29
300 meters	41
Load 1	28
Load 2	73
Load 3	30
Load 4	40
Load 5	10
Load 6	20
Load 7	38
Load 8	45

Subjective Comments: Load 2 was the most unbalanced, while the 49.9 kg stretcher (Loads 5 and 6) was the most balanced load.

8. The straps dug into my shoulders.

Percent of subjects placing a check mark, by condition:

	Percent
150 meters	23
300 meters	41
Load 1	40
Load 2	53
Load 3	18
Load 4	18

Subjective Comments: Half of the subjects complained that Load 2 had straps that dug into their shoulders.

9. The load flopped around and bumped against my body.

Percent of subjects placing a check mark, by condition:

	Percent
150 meters	28
300 meters	41
Load 1	45
Load 2	58
Load 3	38

(Continued)

	Percent (continued)
Load 4	30
Load 5	28
Load 6	30
Load 7	28
Load 8	13

Subjective Comments: Loads 1 and 2 flopped and bumped the most. As with the last two complaints, the 300-meter trials were somewhat worse than the 150-meter trials.

10. The load was too long.

Percent of subjects placing a check mark, by condition:

	Percent
150 meters	19
300 meters	19
Load 1	15
Load 2	13
Load 3	28
Load 4	18
Load 5	15
Load 6	15
Load 7	23
Load 8	25

Subjective Comments: None of the loads were too long.

11. The load was too short.

There were no complaints of this type.

12. The stretcher load kept shifting or sliding around.

Percent of subjects placing a check mark, by condition:

	Percent
150 meters	18
300 meters	28
Load 5	30
Load 6	30
Load 7	20
Load 8	10

Subjective Comments: None of the loads shifted much.

13. The stretcher load kept swinging.

Percent of subjects placing a check mark, by conditon:

	Percent
150 meters	16
300 meters	36
Load 5	30
Load 6	20
Load 7	30
Load 8	25

Subjective Comments: The swinging seemed to get worse at the longer distance.

14. and 15. It was difficult to walk uphill with the stretcher.

Percent of subjects placing a check mark, by condition:

	Percent
150 meters	58
300 meters	61
Load 5	68
Load 6	43
Load 7	78
Load 8	50

Subjective Comments: The majority of the subjects complained that it was indeed difficult to walk uphill with the stretcher and that the front of the stretcher was worse than the back.

16. and 17. It was difficult to walk downhill with the stretcher.

There were no complaints of this type.

18. The load was too wide.

Percent of subjects placing a check mark, by condition:

	Percent
150 meters	6
300 meters	3
Load 1	3
Load 2	25

(Continued)

	Percent (continued)
Load 3	3
Load 4	3
Load 5	0
Load 6	0
Load 7	5
Load 8	0

Subjective Comments: Only Load 2 garnered any complaints of this type.

APPENDIX E

TRACKING STANDARD DEVIATIONS

TOW TRACKING STANDARD DEVIATIONS (MILS)

	SUBJECT																			
	3		5		7		10		14		16		17		19		20		21	
	AZ	EL	AZ	EL	AZ	EL	AZ	EL	AZ	EL	AZ	EL	AZ	EL	AZ	EL	AZ	EL	AZ	EL
RESTED TRIALS																				
TRIAL 1	0.26	0.14	0.17	0.11	0.42	0.12	0.37	0.11	0.35	0.09	0.48	0.11	0.42	0.18	0.31	0.20	0.56	0.20	0.37	0.12
TRIAL 2	0.17	0.22	0.16	0.10	0.44	0.10	0.27	0.15	0.56	0.10	0.32	0.16	0.46	0.12	0.36	0.11	0.41	0.15	0.19	0.08
TRIAL 3	0.17	0.09	0.13	0.06	0.18	0.09	0.27	0.13	0.26	0.11	0.30	0.14	0.24	0.15	0.17	0.12	0.29	0.15	0.15	0.06
150 METER																				
LOAD 1	0.25	0.16	0.24	0.10	0.53	0.16	0.58	0.15	0.48	0.24	0.40	0.18	0.54	0.55	0.66	0.17	0.45	0.22	0.31	0.09
2	0.25	0.22	0.14	0.07	0.99	0.26	0.37	0.19	0.62	0.17	1.05	0.50	0.33	0.15	0.73	0.16	0.41	0.17	0.24	0.10
3	0.22	0.17	0.21	0.11	0.44	0.10	0.31	0.13	0.78	0.56	0.39	0.11	0.42	0.17	0.47	0.21	0.48	0.26	0.19	0.08
4	0.28	0.10	0.24	0.09	0.23	0.12	0.59	0.19	0.66	0.26	0.51	0.15	0.92	2.52	0.38	0.17	0.54	0.21	0.24	0.07
5	0.27	0.15	0.55	0.59	0.53	0.15	0.52	0.29	0.64	0.12	0.43	0.10	0.26	0.16	0.78	0.24	0.59	0.21	0.23	0.11
6	0.20	0.27	0.27	0.09	1.59	0.21	(0.45)	(0.18)	1.43	0.29	0.33	0.09	1.09	1.60	0.31	0.14	0.35	0.15	0.19	0.07
7	0.22	0.10	0.19	0.09	0.56	0.19	0.34	0.15	1.15	0.24	0.31	0.13	0.89	0.45	0.70	0.19	0.87	0.49	0.34	0.06
8	0.31	0.11	0.16	0.08	5.91	2.03	0.43	0.19	0.78	0.20	0.52	0.10	0.27	0.13	0.67	0.54	0.41	0.22	0.20	0.10
9	0.26	0.17	0.24	0.09	0.49	0.12	XXXX	XXXX	0.44	0.14	0.37	0.07	XXXX	XXXX	XXXX	XXXX	0.27	0.12	XXXX	XXXX
10	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	0.22	0.11	XXXX	XXXX	0.26	0.09
11	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	0.34	0.14	XXXX	XXXX	XXXX	XXXX	0.42	0.12	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
12	0.27	0.12	0.25	0.08	0.49	0.09	0.34	0.13	0.38	0.15	0.53	0.13	0.64	0.66	0.31	0.12	0.38	0.15	0.26	0.13
13	0.29	0.12	0.30	0.08	0.43	0.13	0.33	0.15	0.54	0.15	0.28	0.13	0.44	0.34	0.27	0.18	0.38	0.13	0.30	0.09
300 METER																				
LOAD 1	0.18	0.11	0.22	0.08	0.43	0.10	0.34	0.15	2.45	0.29	0.44	0.19	1.07	0.26	0.29	0.20	0.94	0.46	0.31	0.11
2	0.27	0.10	0.13	0.07	0.35	0.09	0.29	0.18	0.63	0.19	0.55	0.13	0.36	0.18	0.31	0.17	0.59	0.17	0.35	0.13
3	0.65	0.29	0.20	0.08	0.49	0.16	0.37	0.12	0.70	0.15	0.32	0.14	0.28	0.12	0.35	0.23	0.44	0.29	0.19	0.08
4	0.23	0.09	0.26	0.09	0.35	0.15	0.29	0.15	0.53	0.16	0.33	0.10	0.19	0.14	0.36	0.15	0.55	0.19	0.22	0.12
5	0.17	0.12	0.25	0.10	0.45	0.13	0.29	0.11	0.59	0.18	0.42	0.19	0.34	0.19	0.55	0.20	0.46	0.18	0.16	0.08
6	(0.28)	(0.13)	0.21	0.09	0.60	0.13	0.20	0.24	2.56	0.34	0.47	0.15	0.32	0.11	0.58	0.16	1.00	0.21	0.17	0.11
7	0.18	0.09	0.25	0.08	0.28	0.10	0.61	0.12	3.14	0.51	0.43	0.15	0.42	0.24	0.44	0.12	0.36	0.23	0.33	0.10
8	0.31	0.09	0.40	0.25	0.40	0.15	0.37	0.11	0.57	0.16	0.48	0.21	0.56	0.24	0.34	0.13	0.43	0.11	0.20	0.08

DRAGON TRACKING STANDARD DEVIATIONS (MILS)

	SUBJECT																			
	2		4		6		8		9		11		12		13		15		18	
	AZ	EL	AZ	EL	AZ	EL	AZ	EL	AZ	EL	AZ	EL	AZ	EL	AZ	EL	AZ	EL	AZ	EL
RESTED TRIALS																				
TRIAL 1	1.35	1.68	2.89	1.95	1.41	0.72	1.93	1.17	2.35	0.52	1.00	0.71	1.44	0.71	0.88	0.43	1.22	0.60	1.97	0.63
TRIAL 2	1.14	1.23	1.65	0.91	1.04	0.84	0.87	0.53	0.92	0.50	0.70	0.63	1.11	0.69	0.86	0.55	1.37	0.63	4.60	1.99
TRIAL 3	0.73	0.59	1.21	0.73	1.02	0.83	3.15	3.29	0.73	0.81	0.92	0.49	1.27	0.61	0.95	0.31	1.06	0.40	1.65	1.15
150 METER																				
LOAD 1	1.19	1.08	5.39	2.05	1.83	1.10	1.76	1.81	2.11	1.02	1.13	0.89	1.88	1.35	1.09	0.79	3.12	1.61	4.66	4.71
2	1.60	1.38	6.79	3.99	1.55	1.13	1.92	1.86	1.13	0.75	1.94	1.14	1.11	0.84	1.42	0.80	2.64	1.16	5.11	4.27
3	2.19	1.40	3.15	2.12	3.71	1.73	3.18	1.46	3.14	0.89	1.10	0.78	2.26	1.14	1.11	0.71	1.20	1.15	2.33	1.94
4	1.80	1.05	2.60	3.55	3.16	2.32	1.52	1.02	1.58	1.76	1.15	0.98	2.50	1.50	1.52	0.78	2.18	0.93	1.91	1.54
5	3.40	1.64	4.12	5.16	2.40	1.09	3.12	0.86	3.52	1.51	(1.81)	(1.54)	2.69	2.18	1.27	0.64	1.35	1.12	2.96	2.62
6	1.32	1.18	1.82	2.44	1.45	1.15	1.90	1.40	1.59	0.81	4.93	5.24	2.94	1.88	1.90	0.90	1.20	1.33	1.79	2.31
7	1.75	1.49	5.20	4.70	1.26	0.81	1.91	1.04	3.25	2.31	1.03	0.93	2.54	2.90	1.67	0.99	1.74	1.37	2.50	2.09
8	2.04	0.87	2.03	2.78	1.78	0.98	3.29	1.78	1.26	0.52	1.36	0.82	1.89	1.33	1.30	0.98	1.81	1.76	2.94	3.11
9	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	1.13	1.34	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	1.72	1.17
10	1.56	0.77	XXXX	XXXX	2.25	0.69	0.94	0.65	1.61	0.96	XXXX	XXXX	XXXX	XXXX	1.52	0.58	1.09	0.39	XXXX	XXXX
11	XXXX	XXXX	1.60	1.59	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	1.69	1.80	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
12	2.43	2.36	2.22	2.02	1.45	0.91	4.68	1.95	1.29	1.17	1.08	0.84	3.06	1.03	3.10	1.17	1.34	0.59	1.94	1.79
13	1.24	0.56	2.34	2.24	1.61	1.34	2.68	2.65	1.10	1.05	0.90	0.65	4.15	2.93	5.82	6.42	0.87	0.89	1.71	1.44
300 METER																				
1	3.58	4.33	2.29	1.91	1.66	1.39	1.51	2.02	0.88	0.76	1.00	0.81	3.22	1.54	1.06	0.49	1.55	1.25	4.70	5.49
2	2.76	2.66	1.56	1.25	2.87	3.33	3.45	2.46	5.17	2.08	0.60	0.78	4.49	2.12	2.61	1.72	1.43	1.35	6.52	1.96
3	1.58	2.04	2.17	1.30	1.67	1.48	1.35	1.33	2.06	1.03	1.01	0.73	8.83	4.28	1.02	0.81	1.54	0.95	6.32	6.77
4	1.55	1.00	2.81	1.64	2.47	2.32	2.38	1.75	2.12	2.00	0.91	0.83	6.25	2.71	0.99	0.70	1.29	0.86	8.39	7.64
5	2.67	1.57	3.04	2.54	(2.05)	(1.82)	1.36	1.39	1.64	1.42	1.00	0.70	1.60	1.09	0.94	0.63	1.65	0.59	4.33	3.85
6	4.20	3.00	2.08	2.07	2.31	1.75	2.54	1.33	2.42	2.82	1.04	0.63	2.93	1.46	1.67	0.71	1.83	1.08	6.43	5.11
7	2.92	1.64	1.41	1.70	1.68	1.24	1.54	1.25	4.91	1.01	0.94	1.40	3.11	2.38	1.23	0.61	1.23	0.71	1.44	1.86
8	2.07	1.35	2.52	2.13	1.68	1.25	1.15	0.89	1.12	0.91	1.19	0.96	4.39	5.37	1.31	0.73	1.00	0.65	7.83	3.17

APPENDIX F

PORTAGE TIMES

PORTAGE TIMES

(Seconds)

	150 Meters													300 Meters								600 Meters				
Loads →	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3	4	5	6	7	8	None	1	2	3	4
Subject																										
2	60	66	60	61	62	72	78	77	-	72	-	75	67	156	143	136	136	157	153	172	161	162	-	-	217	-
3	49	68	44	50	65	77	78	82	69	-	-	56	51	121	139	121	110	156	-	167	187	171	-	-	-	208
4	61	69	58	61	68	70	82	78	-	-	74	69	70	130	140	122	124	144	147	168	173	178	-	-	209	-
5	48	51	45	51	56	59	86	72	78	-	-	65	67	116	118	105	109	121	129	177	169	157	-	267	-	-
6	63	74	61	62	81	85	92	91	-	91	-	84	73	146	170	142	153	-	156	177	176	193	-	-	282	-
7	55	56	48	55	72	62	77	78	72	-	-	65	73	130	174	142	139	153	157	161	172	158	-	-	-	241
8	56	60	49	53	77	65	71	84	-	78	-	65	63	114	121	109	137	129	121	179	203	159	255	-	-	-
9	52	49	45	52	59	56	78	83	-	69	-	63	57	104	123	111	123	162	159	162	164	147	-	-	192	-
10	58	66	57	63	68	64	78	82	-	-	67	84	98	134	150	128	135	159	162	197	185	181	-	280	-	-
11	51	56	55	55	64	68	74	74	66	-	-	58	53	112	124	110	108	155	170	195	167	153	-	-	215	-
12	55	59	51	54	70	78	86	86	-	-	62	64	68	119	130	109	134	155	160	187	167	167	233	-	-	-
13	60	67	54	57	72	70	82	78	-	96	-	71	95	133	140	122	128	155	164	169	177	162	272	-	-	-
14	60	67	60	63	78	70	91	92	91	-	-	65	71	130	139	120	135	170	155	173	168	164	-	-	-	266
15	69	83	71	64	82	85	72	86	-	95	-	83	93	176	173	160	161	173	170	185	197	212	273	-	-	-
16	60	69	57	59	70	72	84	71	96	-	-	64	73	132	149	150	155	160	155	176	177	169	-	286	-	-
17	61	83	70	76	85	82	83	78	-	-	95	92	110	164	167	153	154	164	155	203	179	169	-	300	-	-
18	56	57	51	50	56	56	61	69	64	-	-	58	57	116	123	109	119	128	129	162	156	154	241	-	-	-
19	63	65	55	65	70	68	74	74	-	66	-	62	65	133	153	123	123	170	173	164	162	182	-	-	-	246
20	66	69	60	64	85	81	86	86	95	-	-	82	77	160	164	122	135	147	144	167	195	164	-	-	-	245
21	55	57	46	49	56	56	69	61	-	64	-	59	54	116	133	98	99	129	128	156	162	143	-	210	-	-


DAT
ILM